



ABB Review

The corporate technical journal
of the ABB Group

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4 / 2009

Pathways to innovation

Innovation breakthroughs of 2009
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The development of a new product from the initial idea to the final delivery is often a long and complex journey calling for the right decisions and insights at every turn. A successful completion may sometimes also depend on the timely convergence of different factors such as enabling technologies, market conditions and economic, ecological and social aspects. This edition of *ABB Review*, pathways to innovation, presents some of the greatest successes of ABB's labs and research centers of 2009.



Innovating tomorrow's technologies

It is sometimes said that genius is 99 percent perspiration and 1 percent innovation. In showcasing selected breakthroughs in the end-of-year edition of *ABB Review*, we are recognizing the dedication and resolve of the company's scientists and engineers, while bearing in mind that such a brief presentation of the final product often does little justice to the real development work involved. It is thus fitting that besides celebrating selected innovation highlights of the year, *ABB Review* furthermore reports how one of these projects received a prestigious distinction: The Marcus Wallenberg Prize was awarded to three ABB researchers for their work in the area of direct drives: Permanent magnet motors are (in certain applications) able to deliver the required speed and torque directly to the load, so eliminating the intermediate gearbox. This reduces the installation footprint while raising reliability and efficiency.

Another area covered in this edition of *ABB Review* is solar energy. The underlying principle is far from new: In fact the photovoltaic effect was recognized by A. E. Becquerel as long ago as 1839 and predates the commercial use of electricity by several decades. It was not until the 1950s, however, that the effect advanced beyond being a mere curiosity. Following decades of progress in prices and efficiency, the technology is now moving in the direction of price parity – the point at which the cost per kilowatt-hour matches that of conventional generation – at least in advantageous situations. Although ABB is not directly involved in manufacturing photovoltaic cells, it can supply much of the auxiliary equipment for control, protection and grid connection. The new PVS800 converter fulfills the high demands on efficiency, reliability and safety that photovoltaics need in order to be an economically viable proposition.

On a more long-term perspective, *ABB Review* looks at the Desertec Industrial Initiative, an ambitious plan to build large-scale solar power plants in the Sahara and Middle East and link these to Europe with power superhighways – aiming to cover 15 percent of Europe's electricity demands by 2050. With 90 percent of the world's population living within 3,000 km of a desert – a distance over which economic transmission is feasible – the concept is equally applicable in other areas.

Addressing industrial productivity, *ABB Review* presents two new robots. The IRB 2600 sets new standards in terms of its working area and ingress protection, whereas the smaller IRB 120 takes compactness to new levels. A WirelessHART™ transmitter permits the retrofitting of installed fieldbus devices by plugging in to a standard interface, while an optical caliper breaks new ground in the measurement of paper surfaces.

Based on the fundamental developments ABB has undertaken to more closely integrate process and substation-automation subsystems, the company is currently completing a major integration project in a refinery using ABB's Extended Automation System 800xA and the IEC 61850 standard.

On the topic of transportation, two marine stories are presented: One introduces the new Azipod® XO propulsion system and the other a monitoring solution to improve maintenance and reliability. The section is rounded off by a report on ABB's traction transformers for high-speed trains.

In the area of connectivity, *ABB Review* looks at the X-Plug, which is set to take the woes out of wiring medium-voltage switchgear control cabinets. As a different, yet equally important form of connectivity, we present ABB's personalized Web platform, which gives customers instant access to the information they want.

I hope that by highlighting these outputs from ABB's innovation and development processes, we are contributing to their impact, and inspiring you to put them to their best use.

Enjoy your reading.

Peter Terwiesch
Chief Technology Officer
ABB Ltd

ABB Review 4/2009

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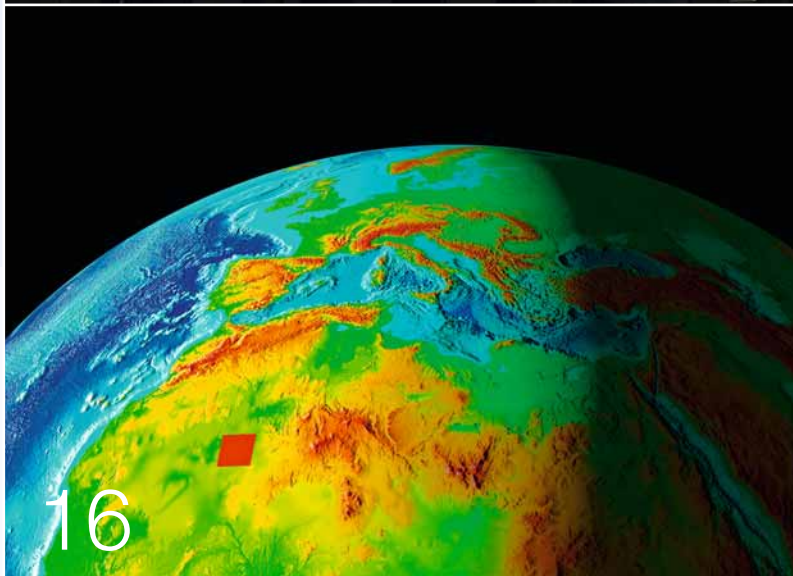
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An innovative 2009

In ABB's labs across the world, scientists and engineers are continuously seeking ways of improving products and enabling new solutions. *ABB Review* presents a small cross-section of the company's innovation breakthroughs of 2009.

Beyond the gearbox

ABB's Direct Drive technology is delivering higher productivity and greater simplicity to the paper industry as well as winning a series of prestigious awards, the most recent being the highly respected Marcus Wallenberg Prize.

As the speed and torque of a conventional induction machine do not necessarily match those of the application to which it is connected, a gearbox performs the conversion. Induction motors are not particularly well suited for low-speed operation. Besides the

fact that their size increases with higher pole numbers, the efficiency and power factor drop with a reduction in speed. ABB's researchers realized this constraint could be overcome if permanent magnets were used because of their ability to provide a strong magnetic flux that enables higher motor torques. Using this knowledge they developed the Direct Drive solution.

This solution consists of a permanent magnet synchronous motor controlled by a low-voltage AC drive. Coupled with the synchronous Direct Torque Control (DTC), it provides better torque characteristics, precise speed control and high efficiency. The transition to Direct Drive technology reduces the



number of mechanical drive components required in many applications. These savings not only lower losses and the floor space required, but also reduce overall complexity and downtime.

For more information see "No gears required" on page 12 of this edition of *ABB Review*.

Wireless rescue

The arrival of wireless standards, such as WirelessHART™, has allowed ABB to develop an upgrade wireless adapter, which can be fitted to existing HART instruments.

It has been estimated that only 10 percent of the 30 million HART fieldbus instruments installed since 1989 have a pathway back to a host, such as a distributed control system. This means valuable information, which could be used to ensure the timely maintenance of assets in the field, is stranded. Access to this data could be achieved by adding a wire-

less network to transmit the information from each instrument back to the host system. WirelessHART™ provides a cost-effective pathway back to a host asset management system, such as the ABB Asset Vision Professional, which has built-in asset monitors for HART instruments. These are used to check instrument maintenance conditions and provide additional information to assist with fault finding.

ABB's WirelessHART upgrade adapter (NHU200-WL) can be connected anywhere within the 4 to 20 mA loop used by the instrument.

It has been developed to complement wired networks for situations where installation costs are high or when a



second maintenance network is beneficial.

For more information see "Unlocking stranded information" on page 27 of this edition of the *ABB Review*.

Integration in a refinery

ABB is providing process-control and power-management systems based on its Extended Automation System 800xA to nine of Petrobras' 12 Brazilian refineries – solutions that will help increase production by a massive 40 percent.

In many industries, power management is a vital topic in terms of costs and an important prerequisite for reliable operation. ABB's Power Management System (PMS) is based on System 800xA and uses the IEC 61850 standard for substation automation, facilitating the integration of intelligent electrical devices (IEDs). The system allows process and power automation systems to be integrated, permitting higher productivity through more far-reaching optimization of plant operations.



The introduction of IEC 61850 in 2004 was an important step forward in terms of simplifying the integration of IEDs. The standard ensures the interoperability between devices and is capable of replacing all the various protocols in the substation-automation domain.

The REPAR refinery, located in Brazil's Parana state, is one of Petrobras' most important downstream production units. As part of a larger expansion project (also involving several new

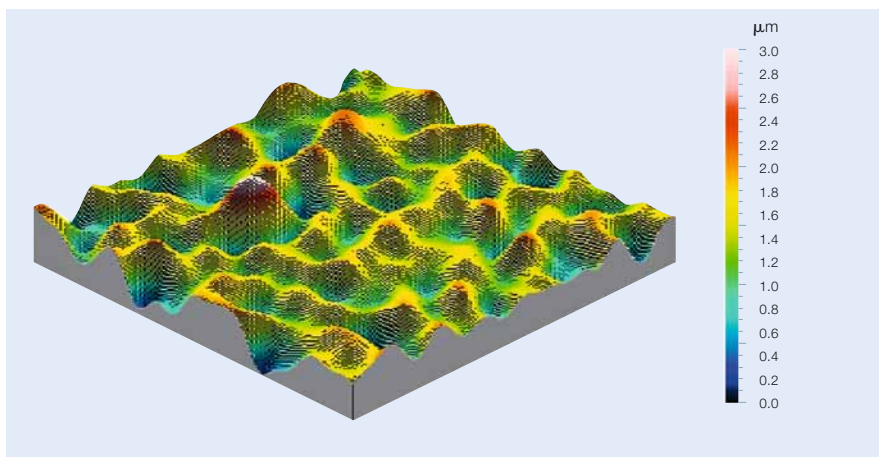
substations and increasing the energy available to the plant) ABB is currently delivering an integration solution using its System 800xA PMS that will fully integrate the process-control and power-management systems, greatly boosting plant productivity.

For more information see "Refined integration" on page 47 of this edition of *ABB Review*.

Paper run

The paper industry has long sought a caliper sensor that is accurate, reliable and does not mark or break the sheet. ABB has launched just such a sensor, enabling papermakers to continuously measure one of their most critical parameters on even the most demanding paper grades.

Caliper, or residual sheet thickness, is a need-to-have measurement for almost every papermaker. However, reliable caliper measurement has proven elusive. Traditionally, this measurement has been achieved through the use of dual-sided, contacting caliper sensors. These run small "skis" over the paper and record the thickness change with an accuracy of better than 1µm. On a microscopic level, however, some paper grades resemble the Swiss Alps and therefore pose tremendous challenges for these



contacting skis. As a result, paper sheet damage, inaccurate measurement and poor control can occur.

ABB's new optical caliper sensor overcomes these problems. Based on a confocal displacement measurement technique, this sensor significantly reduces the error from light penetration that may occur in laser triangulators (ie, the glow-ball effect). It surpasses

all other optically based caliper sensors in terms of accuracy, resolution and reliability and, last but not least, it helps papermakers reduce their energy needs, use fewer raw materials and make a better quality product.

For further information, see "Innovation in action" on page 33 of this issue of *ABB Review*.

Sunlight by cable

ABB's PVS800 central solar inverter is a reliable, economic and compact solution for connecting photovoltaic arrays to the grid. It converts the DC output of the photovoltaic panels to the AC the grid requires.

Photovoltaic energy is rapidly moving toward price parity – the point at which the price per kilowatt-hour of photovoltaic energy matches that from conventional sources. It is estimated that within five years, photovoltaic energy prices will match peak prices in areas with high isolation such as California or Italy. But already today, driven by environmental awareness, photovoltaics are experiencing rapid growth.

Features of the PVS800 inverter include reliability, longevity, fast and easy installation, a modular and expandable design and high compactness (it is the most compact design on the market). The inverter is suitable for both dedicated photovoltaic power plants and for photovoltaic systems as can be found, for example, on the roofs of commercial and industrial buildings. The PVS800 is available with power ratings from 100 to 500 kW.



Power can be fed directly into the distribution grid or, using a transformer and switchgear, into the medium-voltage grid.

For more information see "From light to power" on page 22 of this edition of *ABB Review*.

Slim switchgear for wind turbines

Traditional wind-turbine switchgear is not known for being slender, and certainly is not capable of fitting through a tower door. Rather, it is installed either inside the tower base or in a small secondary substation built alongside the tower.

In the former scenario, the equipment must first be placed on the base before the tower is fitted over the equipment. Replacing the switchgear inside has – until now – been a challenge.

As part of its SafeWind portfolio, ABB has introduced a slim, compact and flexible 36 kV circuit-breaker panel for wind applications that enables simplified installation and replacement. Only 420 mm wide, the entire breaker can easily fit through the tower door of a wind turbine during installation. This circuit-breaker panel, SafeRing 36, is a part of the SF₆-insulated ring main unit product range for 36 kV secondary distribution networks.

SafeRing 36 will be discussed more fully in an upcoming edition of *ABB Review*.



A crystal clear solution

It is estimated that 2 percent of all electricity generated is lost due to distribution transformer inefficiency. An inventive approach to improving this number and achieving a lower total cost of ownership is the use of amorphous metal.

Amorphous metal is a unique alloy whose structure of metal atoms occurs in a random pattern. It is this structure that makes it possible to minimize no-load losses in transformers. Traditionally, cold-rolled grain-oriented (CRGO) silicon steel, which has an organized crystalline structure, has been used to manufacture transformers. However, the higher resistance to magnetization and demagnetization because of the crystalline structure leads to higher core losses. Thus, as part of ABB's commitment to increasing efficiency and to sustainability, the company developed an amorphous core distribution transformer for dry and oil-filled types.



losses and add it to the cost of a transformer. Therefore, it is more economical for a utility to invest in a low-loss amorphous core transformer even though the material weight of an amorphous core is slightly higher than for conventional technologies. In the future this will be a significant driver for energy savings and reduced greenhouse gas emissions.

This new transformer reduces no-load losses by 60 to 70 percent. The no-load loss of a transformer is particularly important because most of the time distribution transformers are operated well below their nominal load. Increasingly, utility companies consider the no-load losses when they evaluate different transformer technologies. They attribute a value to the

losses and add it to the cost of a transformer. Therefore, it is more economical for a utility to invest in a low-loss amorphous core transformer even though the material weight of an amorphous core is slightly higher than for conventional technologies. In the future this will be a significant driver for energy savings and reduced greenhouse gas emissions.

Subsea transformer

ABB has been developing subsea transformer technology for almost 25 years. Such specialist transformers are used to power pumps and compressors and other electrical equipment deep beneath the sea's surface to keep oil and gas wells productive for longer.

ABB has been developing subsea transformers that can operate at depth, under pressure, since 1985. These developments have enabled the oil and gas industry to exploit deep-water oil fields 50 km or 100 km offshore. These transformers are rugged and reliable. They are housed in a special high-grade steel casing able to cope with the high pressure

and corrosive action of deep sea saltwater. Their components are extremely robust since repairs cannot be made easily, due to their relative inaccessibility during operation.

To avoid pressure problems at depth, all air- and gas-filled vaults within the outer casing are eliminated by immersing components in a high-class insulating oil with a low expansion coefficient to cope with elevated operation temperatures. Rigorous tests carried out on all components have ensured that all 15 subsea transformers currently installed are operating reliably and safely. ABB remains the world's only manufacturer of subsea transformers capable of delivering reliable power underwater with minimal losses.



For more information, see "Under pressure" on page 25 of this edition of the ABB Review.

Navigating by four colors and intuition

The name “Living Space” stands for a new generation of building-system technology from Busch-Jaeger, a member of the ABB Group. The innovative interface concept is applied in the company’s Busch-priOn® control panel, incorporating the philosophy that while technical systems grow ever more sophisticated, they should remain intuitive and simple to operate.

The KNX-bus-based control systems allow comfort functions such as light, heating, blind settings and also home entertainment systems to be controlled from a single panel using a single interface philosophy. The system furthermore allows the definition of complete scenarios of settings appropriate to a given situation.

Busch-priOn was developed in a customer-focused process with special emphasis on ergonomics and ease of use. The objective was to make elementary functions such as “lights on” as simple as flicking a switch while passing by. More complex functions should not be significantly more difficult to access.

The control panel is based on a 3.5-inch TFT display and a knob that can be both rotated and pressed, much like those found in cars or on mp3 players. The background color of the display changes to reflect its present functional mode: yellow for lights, blue for blinds, orange for heating and air conditioning and magenta for scenarios – a system that can be understood internationally and independently of language.

Busch-priOn is rounded off by elegance of design and technical perfection.

Busch-priOn will be discussed more fully in an upcoming edition of *ABB Review*.



A complete range to Relion®

ABB’s Relion® portfolio is the first protection relay product family that covers the complete application range, from basic distribution to high-end transmission applications – globally – and conforms to the native IEC 61850 standard.

The Relion product family now covers the widest range of products for the protection, control, measurement and supervision of power systems for any transmission and distribution application, thus ensuring security and reliability regardless of the operating environment. For the first time in the industry, the IEC 61850 standard for modeling of data and applications has been incorporated into an entire product family.



This unique feature enables ease of use and a more efficient experience for customers.

The comprehensive Relion portfolio offers both ready-to-use solutions and customization possibilities for specific applications. It is a common tool for application and communication configuration as well as disturbance handling, ensuring engineering efficiency. Relion is backed by ABB technology, global application knowledge and experienced technical support

throughout the life cycle of the products. Two new families within the Relion portfolio are the 615 series for distribution applications and the 670 series for transmission.

Within arm's reach

The IRB 120 robot is the smallest addition to the ABB family of single-armed robots. It is ideally suited to a wide range of tasks, including the handling and assembly of small, delicate components of up to 3 kg in weight.

The IRB 120 offers all the functionality of other ABB robots but in a much smaller package. It has a single articulated arm designed to mimic the reach of a human arm. Its numerous mounting options mean it can be arranged to minimize its footprint within a production line. Its slim wrist and internally routed cables allow it to be used in tight locations, and the easy-to-clean surfaces make it ideally suited to applications requiring dust-free environments.

The robot is light, weighing in at just 25 kg, and features the best path accuracy and motion control on the



market. Smooth movement and accuracy are achieved using ABB's new lightweight (27.5 kg) IRC 5 Compact controller, the latest addition to ABB's comprehensive IRC 5 family of robot controllers. The combined weight of the IRB 120, its IRC 5 Compact controller, floor cables and FlexPendant is less than 60 kg, providing a truly compact, lightweight robotic system.

ABB has many years of experience in the automation business and is partic-



ularly well equipped to automate production processes. The new compact IRB 120 robot and IRC 5 Compact controller will together extend ABB's automation solutions to industries concerned with the assembly and handling of small, complex components and devices.

For more information see "Dexterous and articulate" on page 39 of this edition of the *ABB Review*.

Extended reach and swift action: the new IRB 2600 robot

With the launch of its new IRB 2600, ABB is setting a new benchmark in terms of speed, accuracy, compactness, mounting flexibility and protection for a robot of the 6 to 20 kg payload range.

The new IRB 2600 permits a range of mounting variants ranging from floor to shelf, wall and even inverse mounting. This huge flexibility, combined with the robot's compactness, helps make the robot at home in applications where space is at a premium.

Another strength of the new robot is its large working range. For the larg-



est of the three subvariants, this extends to 1,174 mm below the robot's base plate (ideal for shelf-mounted applications serving injection molding machines) and 1,853 mm forward of its main axis.

The IRB 2600 is also at the forefront of providing protection options. Ranging from hostile foundry environments, where it must withstand high temperatures or even droplets of molten metal, to ultraclean environments where it must avoid contaminating photovoltaic-cell assembly lines or bread packaging lines, the IRB 2600 can fulfill a broad range of protection requirements. All variants feature IP67 ingress protection, which means they must survive submersion in up to 1 m of water, and be totally resistant to dust ingress.

For more information on the IRB 2600, see "The extended-reach robot" on page 42 of this edition of *ABB Review*.

No gears required

ABB's Direct Drive solution meets the challenges
of the world's most demanding processes

Markku Haikola

ABB has been delivering drive systems for papermaking machines for over 100 years. This wealth of experience has now yielded a Direct Drive system that incorporates all the features a paper production drive system needs.

This system is based on permanent magnet synchronous motor technology and provides better torque characteristics, very precise speed control and high efficiency without the need for gearboxes, pulse encoders and auxiliary components. In addition, it cuts electricity and lubrication oil consumption and reduces noise levels.

Since its launch in 2001, this breakthrough Direct Drive technology has been recognized as a revolutionary innovation in the papermaking industry. It has won a string of awards, the most recent being the The Marcus Wallenberg Prize, a major international technology award that recognizes, encourages and stimulates groundbreaking scientific achievements within the fields of importance to forestry and forest industries.

Companies are always searching for new ways of cutting costs while at the same time improving accuracy and efficiency. For many manufacturers this means looking for better ways to run their production lines.

Gearbox-driven systems have been used in many production processes, especially those in the paper industry. Unfortunately because of normal wear and tear, they are the source of downtime, which inevitably leads to costly maintenance. In addition, gearboxes are bulky and take up valuable floor space in and around the machine in question. From a papermaker's point of view, what is needed is a solution that requires less maintenance, less energy and less space, and Direct Drive technology is the answer to these needs.

ABB's breakthrough and award-winning Direct Drive technology has been recognized as a revolutionary innovation in the papermaking industry.

A Direct Drive solution not only reduces the number of mechanical drive components required in many applications, but it actually eliminates the gearbox entirely ¹. This in turn leads to lower installation and maintenance costs, improved reliability and system response (because gear backlash has

been removed) and increased system efficiency.

ABB was the first company in the world to develop a full-scale Direct Drive solution for running and controlling papermaking machines and is the recognized leader in providing drive systems for the pulp and paper industry.

Direct Drive – in a league of its own

Standard induction motors, normally designed to run at between 750 and 3,000 rpm are not particularly well suited for low-speed operation. ABB's Direct Drive solution has been designed to overcome this issue.

The solution consists of a permanent magnet synchronous motor controlled by a low-voltage AC drive such as the ACS800 [1]. The permanent magnet motor is directly connected to the load and can deliver more power from a smaller unit. Coupled with the well-known synchronous Direct Torque Control (DTC)¹⁾ motor control **Factbox 1**, the solution provides better torque characteristics, very precise speed control and high efficiency without the need for gearboxes, pulse encoders and auxiliary components.

The permanent magnet motor follows a radial flux design, which can be either air or water cooled with a permanent magnet rotor. The output power of the motor varies between 17 and 2,500 kW, while the motor voltage can go up to 690 VAC. In most cases, the motor is no bigger than an induction

Factbox 1 Direct Torque Control (DTC)

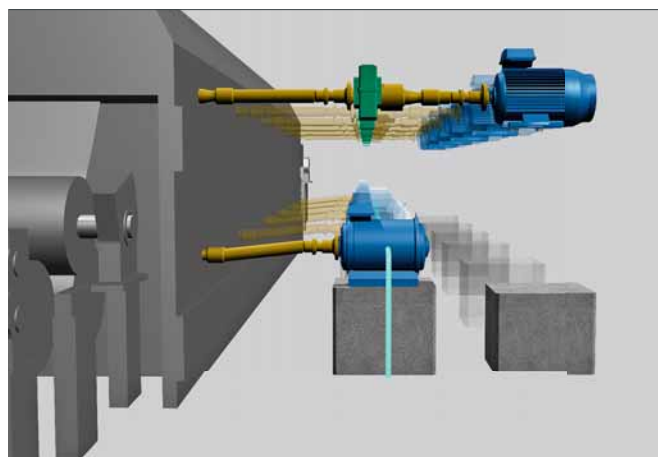
Direct Torque Control – or DTC – is the most advanced AC drive technology developed by any manufacturer in the world and has replaced traditional open- and closed-loop type pulse-width modulation (PWM) drives. It is called direct torque control because it describes the way in which the control of torque and speed are directly based on the electromagnetic state of the motor but is contrary to the way in which traditional PWM drives use input frequency and voltage. DTC is the first technology to control the “real” motor control variables of torque and flux. Because these parameters are directly controlled, there is no need for a modulator – as used in PWM drives – to control the frequency and voltage. This in turn dramatically speeds up the response of the drive to changes in required torque. DTC also provides precise torque control without the need for a feedback device.

High motor efficiency is a trade-off with variable-speed drive efficiency. The total system efficiency is affected by the switching frequency of the variable-speed drive (VSD). Using a low switching frequency will deliver higher VSD efficiency, but will result in greater losses in the output filtering or motor. It is therefore crucial to understand how the type of power supply, switching frequency and output voltage, and the motor design, affect total system efficiency. In addition, the type of power supply unit used also affects the amount of losses.

Footnote

¹⁾ A unique feature of DTC is that it optimizes the switching pulses for better overall efficiency.

1 An illustration showing the space-saving benefits of a Direct Drive system over the gearbox method



2 The first full-size Direct Drive solution ever installed took place at M-real's Äänekoski mill in Finland



Awards and innovations

machine. In fact, when compared to with an induction motor of the same size, a permanent magnet motor can deliver more than twice the torque to a driven shaft. For example, the output torque of ABB's IEC355 permanent magnet motor (330 kW) is 7,433 Nm²⁾ compared with the 3,417 Nm delivered by a 6-pole induction motor of the same size. The optimal speed rating of permanent magnet motors range between 120 and 600 rpm even though operational speeds could exceed 900 rpm. Motor torque can exceed 44,000 Nm for output power ranges of between 2,000 and 2,500 kW.

The Direct Drive solution consists of a permanent magnet synchronous motor controlled by a low-voltage AC drive such as the ACS800.

The construction of the traditional synchronous motor is more complicated than that of the asynchronous motor, so it requires more maintenance. However, the permanent magnets in the ABB motor simplify its construction by creating a constant flux in the air gap, thereby eliminating the need for the rotor windings and the brushes normally used for excitation in synchronous motors. This solution saves on motor maintenance as the

permanent magnet motor is very robust and the maintenance it requires is similar to that of standard AC induction motors.

Since the permanent magnet motor is synchronous, there is no rotor slip, meaning that very accurate static rotors speeds are possible. In addition, the absence of rotor slip eliminates the need for slip compensation, which in turn helps to improve dynamic motor control. What this means is that the speed of a motor can be controlled with a high degree of accuracy over a wide range.

ABB's permanent magnet motor is quieter than most conventional motors because of the way it is constructed and cooled. If water-cooled frames in particular are used, then the motor can be designed with high power densities and protection classes. Water cooling allows more freedom for drive placement by reducing the exposure of the drive components. This improves overall reliability, especially in harsh environments.

Safety and quality are two attributes that are evident in a permanent magnet motor. The magnet is made from neodymium iron boron (NdFeB)³⁾ and is manufactured to the highest standards in order to obtain the strongest, non-deteriorating magnetic fields needed to produce the desired torques. The good news is that this magnetic

field cannot escape the confines of the motor frame. However, a permanent magnet arrangement always has a strong internal electromagnetic field, producing a terminal voltage while the machine is rotating.

Direct Drive in papermaking machines

In many cases, a decisive factor favoring a Direct Drive solution is the space it saves around the machine. The combination of fewer components and simpler configuration reduces plant engineering hours, facilitates installation, allows more efficient use of floor space, and reduces spare parts inventories.

As permanent magnet technology is helping to eliminate gearboxes across a wide range of industries – for example, it has been successfully used in marine propulsion and wind power generation – the benefits of a Direct Drive solution are of particular importance in the paper industry. Paper-making machines require large numbers of high-accuracy, low-speed drives. Getting rid of the gearbox not only reduces maintenance and space requirements, it also saves energy.

The combination of fewer components and a simpler configuration reduces plant engineering hours, facilitates installation and allows a more efficient use of floor space.

Optimally, the Direct Drive solution should be applied in all sections of the paper making machine. Practical operational speeds, however, are achieved using a mix of conventional induction and permanent magnet motors.

When it all began

The development work for a paper-making machine drive application started in 1995, and the first prototypes were up and running in the lab



Footnotes

²⁾ Rated at 300 rpm

³⁾ NdFeB is the most powerful magnetic material available at room temperature, with high values of flux density at very high values of magnetization. It is also extremely resistant to demagnetization.

The 2009 Marcus Wallenberg Prize winners: Dr. Jouni Ikäheimo, Mr. Vesa Kajander and Mr. Bengt Welin with H.M. King Carl XVI Gustaf of Sweden



Photo: Janne Eriksson

in 1997. By 1999 the DC drive of a dryer section at M-real's⁴⁾ paper mill was replaced by the first factory-made permanent magnet motor. This flawless first installation remained in place for several years.

The board making machine at M-real's Äänekoski mill includes the first full-size Direct Drive solution ever installed **2**. Completed in 2002, it includes both

traditional AC motors (for smaller rolls) and permanent magnet motors (for larger rolls running at low speed), like most of the Direct Drive installations. Currently, there are 29 high-powered permanent magnet motors installed at this site.

Further installations can be found in many countries, including Finland, South-Africa, Germany, Spain, Poland, New Zealand, Australia, the United States and Argentina. In fact most European countries with a major paper industry are now on ABB's Direct Drive list.

ABB is the first company to introduce the Direct Drive solution on an industrial scale. The PMC800 is ABB's most recent solution for the drive system, and to date dozens of gearless and encoderless PMC800 Direct Drive systems are running in processes that produce copy paper, newsprint, fluting, uncoated woodfree paper, machine-finished coated paper and coated box board.

An award-winning concept

Since its launch at the Pulp Paper fair in Helsinki in 2001, ABB's Direct Drive solution has been recognized as a revolutionary innovation in the paper-making industry. In the same year it was awarded the Papex Product Innovation Award in Manchester as well as Le Prix Special du Jury du Grand Prix

de l'innovation by L'Association Technique de l'Industrie Papetière⁵⁾ (ATIP) in Grenoble. In 2004, Frost & Sullivan, a global growth consulting company, recognized the concept by awarding it the Motors, Drives and Power Transmission Customer Value Enhancement Award.

On September 29, 2009, the highly respected Marcus Wallenberg Prize **Factbox 2**, a major international technology award, was presented in Stockholm by H. M. King Carl XVI Gustaf of Sweden to three pioneers within ABB, Jouni Ikäheimo, Vesa Kajander and Bengt Welin (retired) for their breakthrough work in the development of the Direct Drive solution.

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Footnotes

⁴⁾ M-real is the leading primary fiber paperboard producer and a major paper supplier in Europe. It is part of Metsäliitto Group, one of the largest forest industry groups in the world, owned by a cooperative of 130,000 private Finnish forest owners.

⁵⁾ The Special Jury Prize at the Innovation Awards of the Technical Association of the Paper Industry.

Reference

[1] Salo, J. The attraction of simplicity: Permanent magnet machines are here to stay. *ABB Review* 2/2009, 29–34.

Factbox 2 The Marcus Wallenberg Prize

The Marcus Wallenberg Prize is an international prize established in 1980 to acknowledge the lifetime activities and memory of Marcus Wallenberg (1899–1982), the late Chairman of Stora Kopparbergs Bergslags AB (now Stora Enso). He was highly respected in financial and industrial circles, both in Sweden and abroad. Each year the prize recognizes a single research breakthrough by one scientist or a small group (normally two to four people) of collaborating scientists. In the view of the Prize Selection Committee and the Board of the Foundation, the selected breakthrough will have a significant effect on the industries. While rewarding the winner, the prize is also intended to stimulate further research around the globe. Every year up to 500 organizations around the world are invited to nominate candidates for the prize.
Source: <http://www.mwp.org>

New power under the sun

A vision for large-scale solar power from the world's deserts

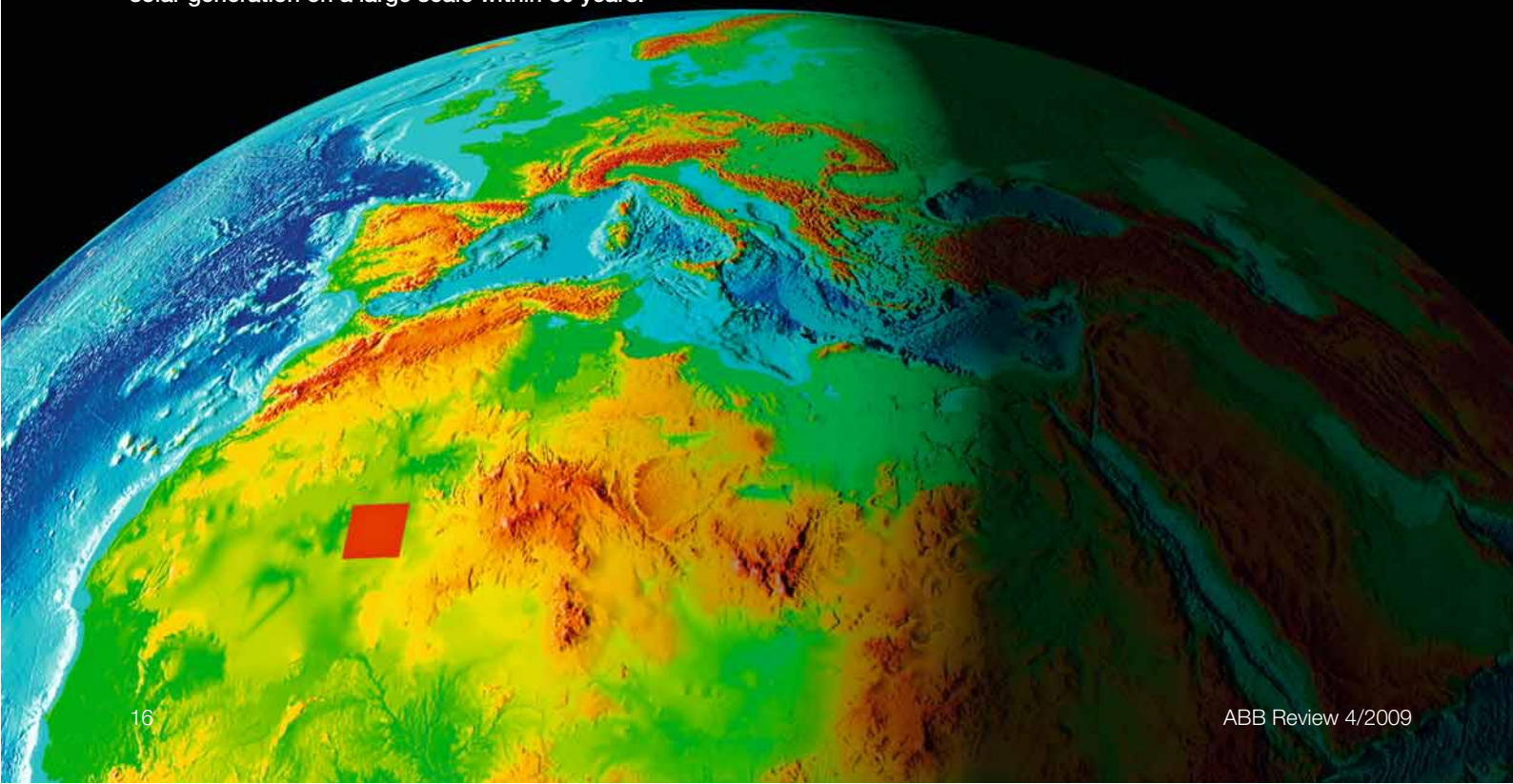
Andreas Moglestue

Without the sun, civilization and indeed life itself would not be possible. Most of our energy, be it fossil fuel, biomass or wind, derives directly or indirectly from the sunlight that reaches the Earth's surface. Mankind has, until now, met most of its growing energy needs by harnessing these derivative sources – mostly in the form of fossil fuels.

With standards of living set to rise further, especially in developing countries, global demand for energy will continue to grow. Furthermore, with the planet's population likely to reach 10 billion by 2050, merely securing basic necessities like as clean water will call for energy-intensive technologies such as desalination plants. How can this ever-growing thirst for energy be satisfied without inflicting grave environmental damage? How can the world's long-term energy supply be assured in the face of limited reserves of fossil fuels?

It is estimated that solar power plants in a desert area of only 90,000 km², that is the equivalent of 300 km by 300 km and only a small fraction of the world's deserts, could meet today's global electricity needs. Furthermore, 90 percent of the world's population lives within 3,000 km of a desert – a distance over which economic transmission is considered feasible with HVDC technology.

The Desertec Industrial Initiative is a working group in which ABB has joined forces with several partners for the advancement of such a project in the EUMENA region (Europe, Middle East and North Africa). The Desertec concept envisages solar generation on a large scale within 30 years.



Human activity across the globe is consuming a staggering 15 terawatts (15,000 GW) of power. To put this into perspective, North Sea oil production contributes about 420 GW¹⁾, and coal production in the United States circa 760 GW.²⁾ Global electricity generation is about 2,200 GW.³⁾

Fossil fuels, which currently cover 80 to 90 percent of global demand, are finite in supply. Nevertheless, they will continue to be the main source of energy for a long time to come: In absolute figures, use of fossil fuels will even rise in the medium-term future. Other sources, be they wind, biofuel or nuclear are all likely to have a role to play in reducing carbon dependency, and many are indeed already growing rapidly both in absolute terms and in market share.

The equivalent of the energy that all of mankind consumes in a year is being delivered every 90 minutes.

There is, however, one source that is providing some 170,000 TW of power to the Earth, 90,000 TW of which reaches the Earth's surface: That is 6,000 times total human consumption. In other words, the equivalent of the energy that all of mankind consumes in a year is being delivered every 90 minutes. In fact, in the time that

the average reader will have taken to reach this point in this article, the Earth's surface will have received the equivalent of six months of North Sea oil production.⁴⁾

Sun and steam

This plentiful source of energy is, of course, the sun. Photovoltaic panels are becoming a common sight on the roofs of buildings or powering such devices as pocket calculators or parking meters, and increasingly also feeding electricity into the grid.⁵⁾ One drawback of solar energy is that it is not constantly available. This problem does not merely occur at night: During the day, cloud conditions can adversely affect performance. Nevertheless, there are regions on this planet in which the latter problem is of little significance. Not only do deserts enjoy the highest levels of delivery of solar radiation, but the weather there is relatively constant and predictable: The sun shines fiercely all day.

Rather than using photovoltaic panels, it is envisioned that the proposed desert power plants will use concentrating solar power (CSP) systems. In such a power plant, reflectors will concentrate the sunlight to heat water to steam. This will be fed into turbines similar to those used in conventional thermal power plants. CSP generation is not only more efficient and economic under desert conditions, but – in contrast to photovoltaic cells, which stop generating as soon as it gets dark – heat can be stored to per-

mit generation to continue at night. Furthermore, the adoption of turbine-based generation systems means that (where appropriate) additional steam can be supplied by combustion-based processes, permitting either a backup source of power or even a mixed generation facility. Cogeneration (involving the use of heat that was generated as a byproduct of other activities) is also an important option.

90,000 TW of solar radiation reaches the Earth's surface: That is 6,000 times total human consumption.

A valuable development initiative

The regions in which these CSP plants are to be built can benefit immensely. Besides immediate advantages such as jobs directly connected to the project, these areas stand to reap more far-reaching benefits thanks to the availability of affordable and sustainable

Footnotes

¹⁾ North Sea oil production is about 6 million barrels per day. The thermal equivalent of a barrel is about 6.1 GJ of energy.

²⁾ About 1,000 megatons of coal are mined in the USA annually. The thermal equivalent of a kilogram of coal is 24 MJ.

³⁾ 19 trillion kWh

⁴⁾ Assuming the average reader reads 250 to 300 words a minute

⁵⁾ See also "From light to power" on pages 22 to 24 of this edition of *ABB Review*.

The Andasol power plant near Guadix in Spain. The parabolic mirrors concentrate the sun's rays permitting steam generation. This is converted to electricity by turbines.



ABB's involvement with Desertec

In July, 2009 ABB signed a "Memorandum of Understanding" for the establishment of the Desertec Industrial Initiative. Why is ABB participating? ABB was already working on the idea of a European grid integrating different kinds of renewable energies in the early 1990s. This included utilizing the sun's energy in deserts to supply Europe with emission-free power. It is only logical that ABB has been talking with the Desertec Foundation and supporting the project for many years. We are convinced that our technology and know-how can contribute to the success of this forward-looking project.

Is this vision of supplying clean power from the desert to Europe technically feasible by today's standards?

The technologies for such a project are already available today and have been tried and tested. We know how to transmit energy over large distances. More than 50 years ago ABB invented high-voltage direct current (HVDC) transmission, the key technology for long-distance power transmission. Since then HVDC has been continuously enhanced to enable the utilization of renewable energies, the interconnection of power grids and to increase efficiency.

In the case of Desertec we are looking at a distance of 3,000 km. How much electrical energy will actually be lost in transmission?

Thanks to our HVDC technology, the power can be transported over large distances with relatively low losses. At a voltage of 800 kV we expect the losses to be around 3 percent per 1,000 km. At a distance of 3,000 km, this means less than 10 percent losses. Long distance connections, however, will likely be an exception. A much more realistic option will be to feed the power from North Africa into the European grid via Southern Europe.

Does ABB have any experience with such long transmission distances?

Currently, ABB is building a high-voltage direct current transmission system in China to transport 6,400 MW of power over a distance of 2,000 km. This is approximately equivalent to the capacity of six nuclear power plants. In addition, we won a contract this July for the world's longest power line. Here, HVDC will connect two new hydropower plants in the north-west of Brazil with the economic metropolis of São Paulo, bridging a distance of 2,500 km.

The technologies for such a project are already available today and have been tried and tested.

Desertec requires very high investment costs. Will it be economical to produce power for Europe in the Sahara?

We wouldn't be supporting the project if we weren't convinced that it can be economical in the medium- and long-term. In the case of Desertec we are looking at a long time frame – decades rather than years. The first pilot projects will be implemented in a couple of years, and by 2050 the solar power plants in the Sahara will be expected to cover 15 percent of the European power requirements. Experts predict the power from solar plants to be competitive within the next 20 years. During this period, the power from conventional energy resources will become more expensive.

How can the energy generated in the desert be fed into the existing European grid considering the fact that the grids are already used to their full capacity today?

Due to increased electricity trading and rising energy demand, the European grid infrastructure will have to be upgraded across international borders anyway – not least because of the planned offshore wind farms in Germany, Belgium and Spain. It can only be advantageous to consider the

integration of the Desertec project from the very beginning.

What about investing more in solar energy storage? Is there any research in this area currently going on at ABB?

First of all, the solar radiation in the deserts is more intense and more regular than it is here in Europe. There are no long, cloudy periods and hardly any seasonal variations. In addition, the use of solar thermal energy allows short-term energy storage. This means that the heat generated during the day can be stored in molten salt storage systems so that the turbines can continue turning during the night. But I expect further improvements in the field of power storage in the future.

Do you think that the solar energy from the desert will replace conventional nuclear, gas-fired and coal-fired power plants?

Desertec is a visionary project, which takes Europe closer to a carbon-neutral power supply. But it will take some time until the first power from the desert will flow to Europe. Therefore, the energy demand must be covered by a broad mix. That's why we will still need conventional energy generation today and in the future.

Sceptics say that the different interests of the countries involved in Europe, North Africa and the Arabian world could represent an obstacle to this project...

This is indeed a challenge and a reason why the initiative plans to spread the power plants across the entire North African and Middle Eastern region and to transport the power to Europe via several "energy bridges." I am confident that the political hurdles will be overcome when the project shows that it is economically profitable. This is something the African and Arabian countries will benefit from as well.

In what way?

Solar energy could become a major export for these countries, generating added value from a resource that is

available in abundance – sunlight. This will create new jobs, drive technological development and increase prosperity. And we must not forget that these countries will be able to use the Sahara power themselves, for example to desalinate seawater. The production of drinking water from seawater is very energy-intensive. The power from the Sahara could solve two problems at once.

The financing of the project still remains unresolved. Will ABB contribute to the costs?

It is ABB's aim to supply the technology for the Desertec project, and by doing so help to ensure its feasibility and reliability. These are important prerequisites for investors.

Peter Smits was interviewed by Melanie Nyfeler, Communications, ABB Switzerland



Peter Smits is the regional manager of ABB in Central Europe and the CEO of ABB AG, Germany.

Peter Smits co-initiated the Desertec Industrial Initiative on behalf of ABB.

energy. For example, desalination plants can be built for drinking water and to serve agriculture, totally revolutionizing the economic prospects of what are today disadvantaged areas.

The technology

As ambitious as the technical realization may sound, the largest hurdles lie in creating the political and economic framework to make such a development possible. The technologies themselves are the lesser challenge, being either available today, or adaptable from such technologies.

Desalination plants can be built for drinking water and to serve agriculture, totally revolutionizing the economic prospects of what are today disadvantaged areas.

The basic idea of solar concentration is not new at all: It dates back at least 22 centuries to when Archimedes proposed using an array of movable mirrors to focus the sun's rays and set fire to enemy ships. Although modern CSP plants serve more peaceful purposes, they use much the same principle: Movable mirrors constantly adjust their orientation according to the sun's position, permitting the maximum of energy to be captured. The reflected light is concentrated on a focal point whose temperature can reach several hundred degrees Celsius.

Power plants using variants of this principle have been in use in California since the 1980s, with further installations being added in various locations over the years. ABB has been involved in the realization of several of these, for example the Extresol project in Spain **Factbox 1**.

Capturing the sun's rays and converting these to electricity are only one part of the story. Once generated, the part of the electricity intended for Europe must be moved over large distances. This is where HVDC (high-voltage direct current) technology comes into play. Converter stations

transform the generated electricity to high voltages, which can then be transmitted over long distances at very low losses. The losses of an HVDC line are about 3 percent for 1,000 km. Furthermore, the power can be transmitted by underwater cables, which would be useful for crossing the Mediterranean and bringing the power to Europe. ABB is a leader in the domain of HVDC technology and has completed or is working on several major projects transmitting power over thousands of kilometers **Factbox 2**.

CSP could meet 15 percent of Europe's electricity demands by 2050.

The Desertec Industrial Initiative

ABB has joined forces with several other manufacturers as well as utilities and finance partners to work towards a realization of these plans in the EUMENA region (Europe, Middle East and North Africa). The Desertec Industrial Initiative strives to build on the recent creation of the Union for the Mediterranean, which was set up to improve and simplify cooperation between the countries of this region. Besides providing public information, the Desertec Industrial Initiative will

Factbox 1 The Extresol power plant

Extresol is a 100 MW CSP installation currently being completed in Spain's Extremadura area. ABB is supplying the control equipment with which the 1,248 parabolic troughs will follow the sun's movement through the sky to an accuracy of 0.03 degrees. Besides this, the company's scope of delivery includes instrumentation, the automation system, motors, drives, low-voltage equipment and substations.

The plant will store excess heat in liquid salt tanks permitting generation to continue when the sun has set.

The first 50 MW are scheduled to commence operation at the end of 2009, with the second 50 MW following six months later.

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perform feasibility studies on such matters as the political, organizational, financial, technological and ecological aspects of the project. It aims to develop a rollout plan describing how to meet the target of covering about 15 percent of Europe's electricity demand by 2050. In a second step, a number of smaller reference projects will be identified and specified, per-

mitting the feasibility of the concept to be tested and demonstrated.

The Desertec Industrial Initiative's ultimate plans for the EUMENA region feature a network of electrical super highways interconnecting the principle areas of generation and consumption across the region ¹. Besides linking CSP plants, this super grid envis-

ages the connection of large onshore and offshore wind farms as well as major hydroelectric plants and even a number of biomass and geothermal facilities.

A network of electrical superhighways will interconnect the principle areas of generation and consumption across the region.

¹ Desertec's vision of a network of power super highways connecting major CSP, wind and other generating facilities to the principle load centers. Source: Desertec.



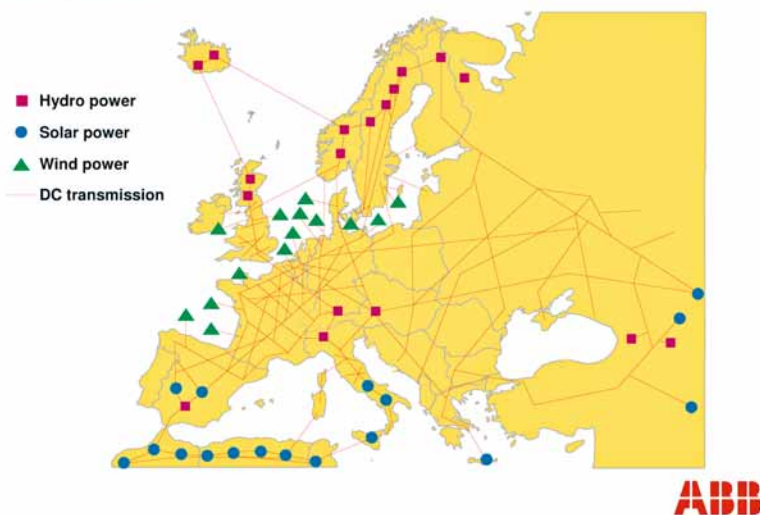
The integration of these installations into the existing grid will entail many challenges, including adapting operations of conventional power plants, and making the grid better suited to the increased use of renewable energy. These are all areas in which ABB can contribute its expertise.

Pioneering role

The Desertec Industrial Initiative was formally established as an organization earlier this year. It does, however, go back in a less formal state to the 1990s, when it was brought into exis-

² The historic slide dating from 1992 in which ABB presents its vision for a future European power supergrid. The concept bears remarkable similarities to that of ¹ (Gunnar Asplund, ABB).

Europe 20XX



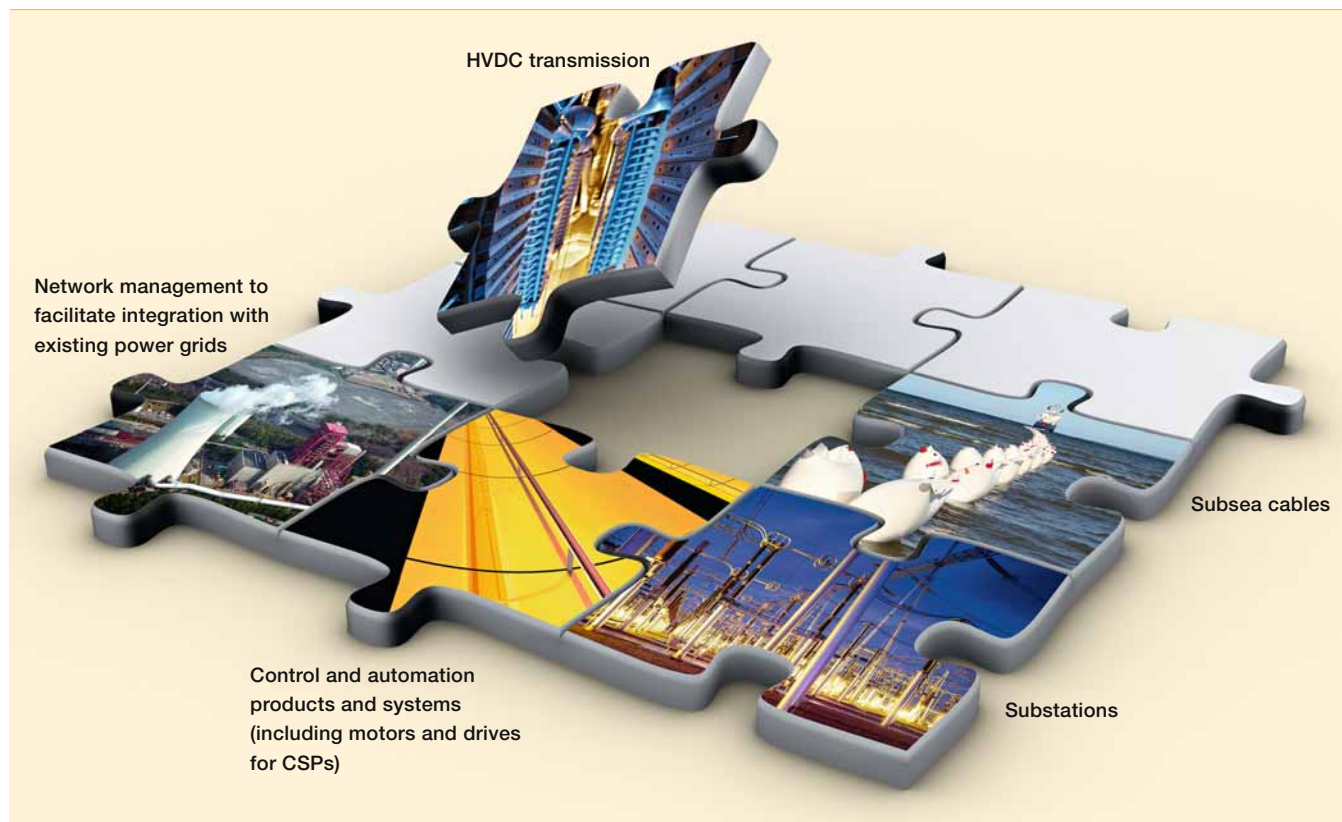
Factbox 2 Major HVDC projects

ABB recently completed a link between China's Three Gorges hydroelectric plant and the city of Shanghai, permitting 3 GW to be transmitted over 1,060 km. This followed on from two other major HVDC links built by ABB, connecting the same power plant to Changzhou and Guangdong. All of these links are rated at 500 kV and 3,000 MW.

ABB has recently won a contract to supply key technology for the Rio Madeira link, a 2,500 km project connecting a hydroplant in Brazil's Amazon region to the city of Sao Paulo. The link will carry 3,150 MW at 600 kV.

ABB has also supplied many underwater HVDC links, most notably the recently completed NorNed link under the North Sea between the Netherlands and Norway. This 580 km link (the world's longest underwater link) carries 700 MW. The cables themselves are also a key ABB technology.

3 The main technologies and know-how that ABB can contribute to Desertec from its present portfolio include:



tence by the German section of the Club of Rome (a global think-tank dealing with political issues, including environmental concerns and the dangers of famine, water shortages, etc.). A study on the topic⁶⁾ by DLR (the German Aerospace Center, Deutsches Zentrum für Luft- und Raumfahrt e.V.) and published in 2006 provided encouraging results.

ABB's part in this goes back further, however: As long ago as 1992, the company presented a vision of Europe's future power grid ². It was drawn up by Gunnar Asplund, who was then development manager for ABB's HVDC technology and presented in a study circle created by ABB to look into the long-term future of power transmission. His vision bears remarkable similarities to that which the Desertec Industrial Initiative is now pursuing.

Green power from a bright sun

The Desertec Industrial Initiative intends to complete feasibility studies with the next three years. Pending a positive outcome of these studies and positive political and financial back-

ing, CSP generation in desert areas looks set to make a significant impact on the energy market of tomorrow. Although pilot installations could start making a contribution at an earlier stage, a large scale contribution to the region's power supply is unlikely to be made for several decades.

In 1992, ABB presented a vision of Europe's future power grid, which was remarkably similar to that which the Desertec Industrial Initiative is now pursuing.

ABB has the know-how and technologies that will permit the company to make a significant contribution to Desertec. Some of these are illustrated in ³. Although the Desertec Industrial Initiative focuses primarily on the EUMENA region, the concept can equally be applied in the world's other desert regions, be they in the Americas, Australia or Asia, and can reduce the world's carbon footprint

on a vast and hitherto unimaginable scale.

For more information on Desertec, please visit www.desertec.org.

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Footnote

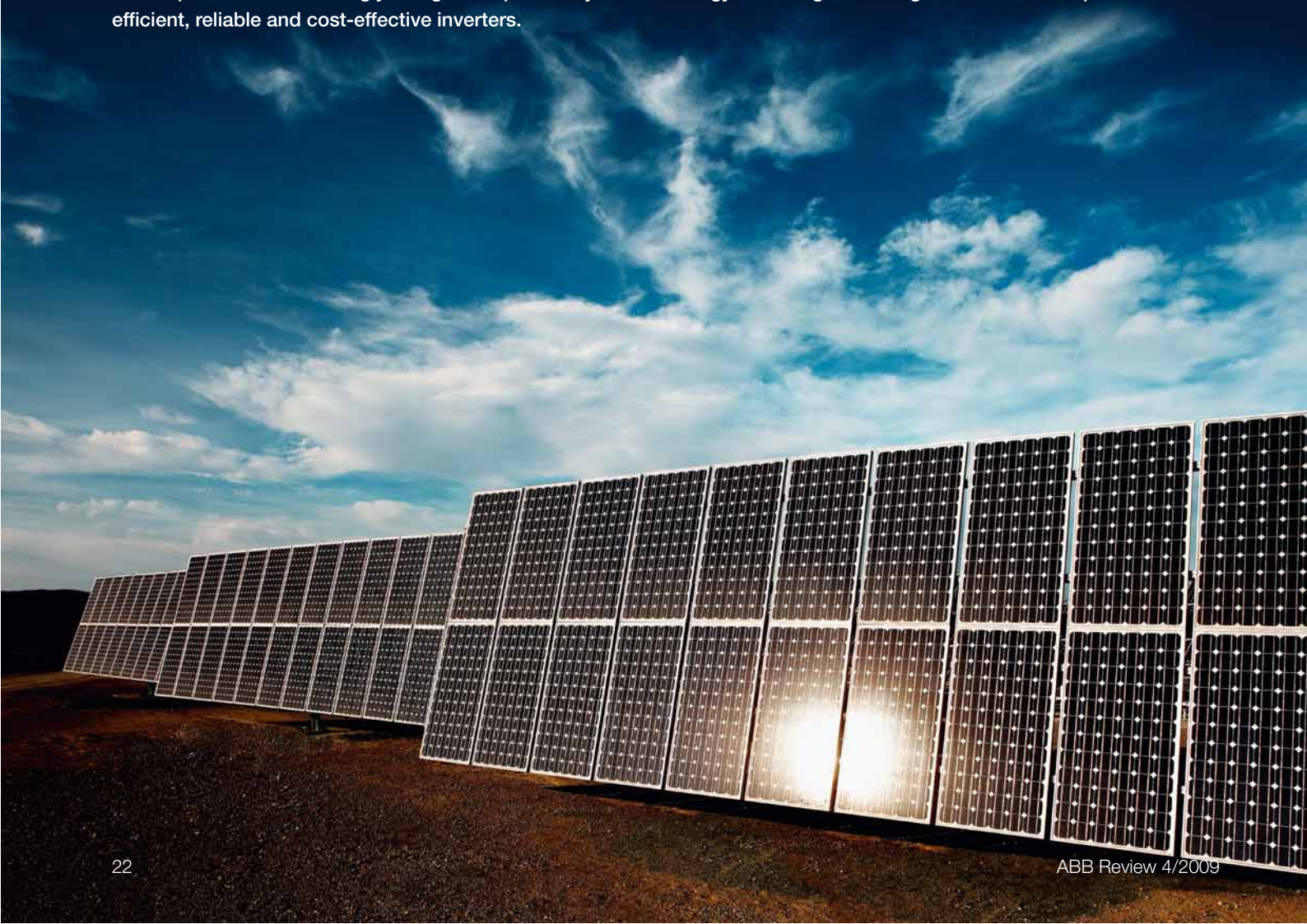
⁶⁾ The study, "Trans-Mediterranean Interconnection for Concentrating Solar Power" was commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

From light to power

Presenting ABB's first solar inverter
Jyrki Leppänen

Solar energy is witnessing a truly stunning growth. Today, about 4,500 MW¹⁾ of photovoltaic capacity is being installed annually worldwide – a figure that was below 100 MW in 1996 – and this expansion is continuing exponentially. The rapid spread is driven by national incentives: mainly by so-called feed-in tariffs. This combination of environmental and industrial policy is causing the market to grow and hence the cost of photovoltaic modules and other components of the photovoltaic value chain to drop. Photovoltaic energy is now rapidly approaching grid parity – the point at which the price per kWh of photovoltaic energy matches that from conventional sources.

Whereas early photovoltaic applications typically supplied energy to off-grid applications, large arrays of photovoltaic panels are increasingly being built specifically to feed energy into the grid. Their grid connection requires efficient, reliable and cost-effective inverters.



ABB's new solar inverter, the PVS800 series central inverter **1**, is designed to be used in both large ground-mounted photovoltaic power plants and photovoltaic systems installed on commercial and industrial buildings. The modular inverters convert the DC that is provided by the photovoltaic modules into AC suitable for the grid. At present, the PVS800 central inverter is available for three power ratings: 100, 250 and 500 kW.

Photovoltaic applications represent an extremely demanding market. As costs and reliability are important enablers to their viability, inverters must not only deliver the highest levels of reliability, but are required to be cost and energy efficient, compact, long-lasting and easy to install. Furthermore, they must operate under extreme environmental conditions, coping with considerable temperature and humidity ranges.

To be permitted to supply power to the grid, the inverter must fulfill stringent demands.

ABB addressed these demands by developing an inverter based on its successful and widely used family of industrial drives, drawing on a plethora of experience and proven concepts. The PVS800 central inverters are based on a drive platform that is used in wind power applications. Whereas industrial drives are typically based on two converters connected by a DC link, a solar inverter requires only a single converter, and also differs in terms of its control and protection requirements.

The inverters are engineered to provide reliable operation for at least 20 years, supported by ABB's proven maintenance and service concepts.

The highlights of the new central inverter product range include:

- Proven technology platform, assuring high reliability and a long operating life

- Compact and modular design, requiring less space and enabling fast and easy installation
- State-of-the-art industrial design, leading to high overall efficiency
- Wide range of remote and local communication, with one supplier for all options
- Life-cycle service and support through ABB's extensive global service network, providing rapid support anywhere in the world

Inverter design

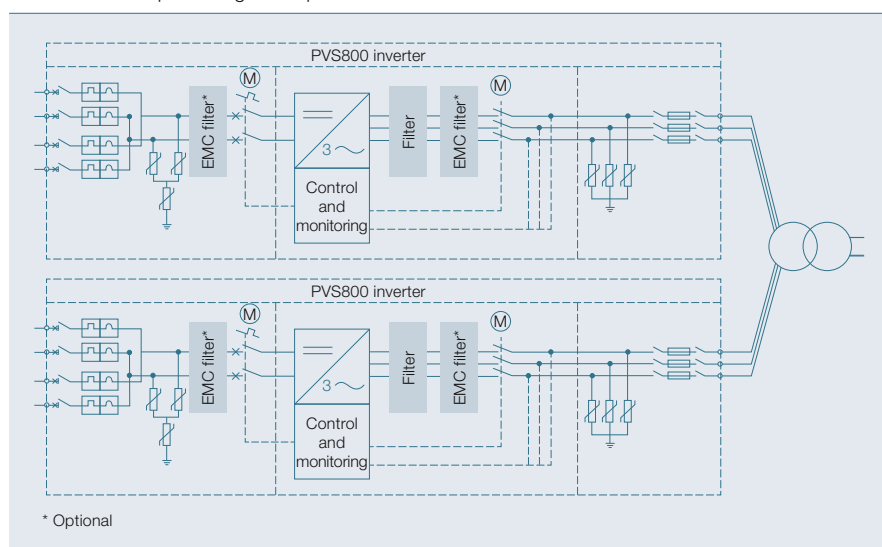
The general design of the inverter is shown in **2**. To be permitted to supply power to the grid, the installation must fulfill stringent demands. This is reflected in the inverter's built-in

safety and protection features on both the AC and DC sides and power-factor compensation. The inverter is equipped with surge protection on both AC and DC sides and with grid-monitoring technology, which is optimized to specific country-dependent requirements. Additionally, the ABB central inverter can meet present and coming grid-support requirements with its reactive power-factor compensation, power reduction and low-voltage ride-through functionalities. These permit, for example, support of the grid during network instability. The inverter has fieldbus interfaces (Modbus, PROFIBUS, CANopen and Ethernet) permitting local and remote monitoring and control.

1 The 250 kW PVS800 central inverter, showing its compact and slim design



2 Design and grid connection in a system consisting of two ABB central inverters. The inverters can handle input voltages of up to 900 V.



Footnote

¹⁾ Figures are peak power production for 2009.

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A maximum power-point tracking (MPPT) algorithm ensures that the energy delivered to the grid from the solar modules is always maximized. This is required because the characteristic (current versus voltage) curve changes as a function of the available light and also of the temperature of the photovoltaic cells. MPPT assures that whatever the conditions, the cells are always working at the point where they deliver maximum power.

Grid connection

In the case of smaller installations, power is usually fed directly into the low-voltage distribution grid. Larger plants typically connect to the medium-voltage grid using a transformer

and switchgear ³ (these are components that ABB can also supply).

In some applications, ABB's central inverter topology allows the parallel connection of several inverters using the same transformer – an important cost-saving factor.

A bright outlook

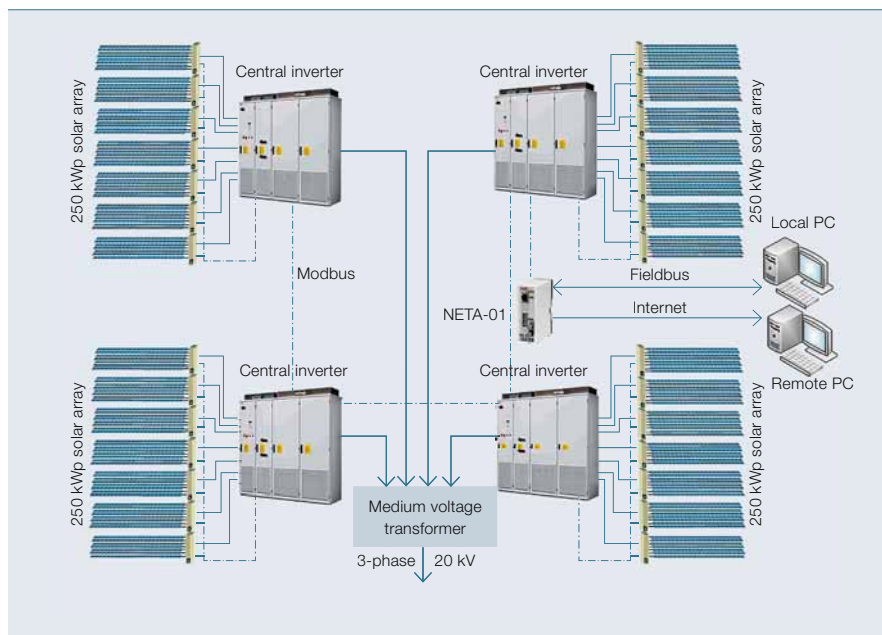
Environmental awareness and falling costs mean the photovoltaic market is continuously growing, and also expanding to new countries. Many governments are supporting the spread of solar energy through advantageous feed-in tariffs. The idea behind these tariffs is that they make investment in clean-energy-generation capacity more attractive, so increasing the market

volume and driving down manufacturing costs. This approach has been extremely successful: It is estimated that within five years grid parity will be reached in locations with high solar insolation and high peak-time electricity prices, such as in California and Italy. Grid parity means that the price of photovoltaic electricity equals the retail price of grid electricity.

In the case of smaller installations, power is usually fed directly into the distribution grid. Larger plants typically connect to the medium-voltage grid using a transformer and switchgear.



³ Data communication and connection of the ABB central inverter



Once grid parity has been reached, the solar markets will experience an even greater boom. While this is desirable from the point of view of reducing emissions and carbon dependency, the influx of photovoltaic electricity will pose challenges for the distribution network and also for the control of the grid. More advanced control strategies will be required. The response is smart grids. These are grids that are attuned to cope with decentralized generation, bidirectional power flows, optimized matching of supply and demand, and feature the associated advanced measurement, monitoring and control systems. ABB is at the forefront of developing, making available and supporting the technologies that will bring about the transition from conventional grids to smart grids. ABB's solar inverters are, of course, smart-grid compatible.

For more information on ABB and solar power, please visit www.abb.com/solar.

Jyrki Leppänen

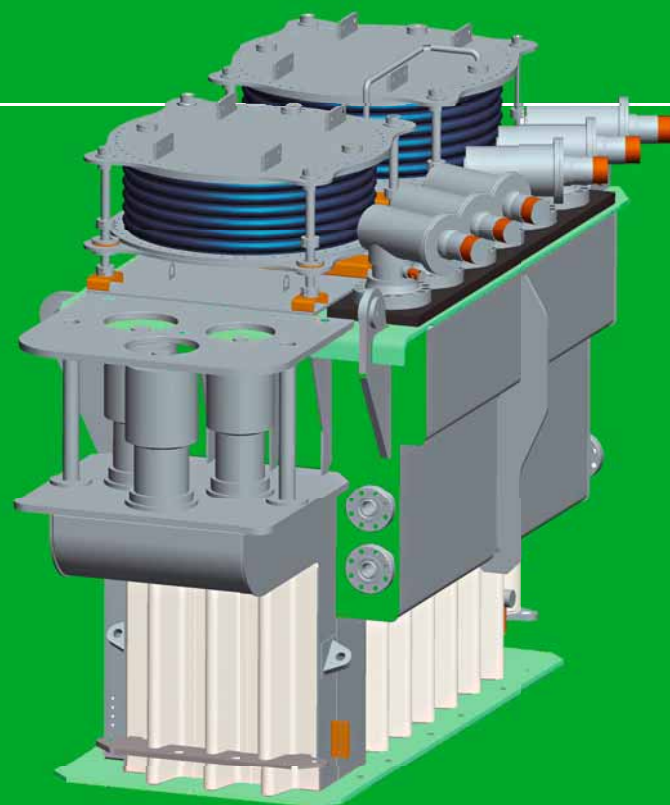
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Under pressure

ABB's subsea transformers

Esa Virtanen, Mark Curtis

Underwater oil fields are among the most extreme environments in which transformers are required to operate. ABB has been developing subsea transformer technology for almost 25 years and remains the world's only manufacturer with installations powering pumps and compressors to extract oil and gas from reservoirs below the seabed, keeping wells productive for longer.



The continued exploitation of offshore oil in shallow waters is declining as these relatively local reserves diminish. Often to maximize oil extraction seawater or gas is pumped into the well to increase pressure and drive the remaining fuel trapped beneath the seabed to the surface. Similar techniques are used in deep water oil fields, at much greater distances from the shore, which now present additional challenges to the industry. Such operations require specialized knowledge and expertise particularly when powering compressors, pumps and motors at depths of several kilometers, possibly 50 km or 100 km away from the shore. To bring power to such remote offshore locations, with low losses, requires transmission at high voltage through subsea cables. Such transmission relies on step-up transformers to increase the voltage

levels for transmission and step-down transformers to reduce the voltage to a suitable level to operate the specialist electrical equipment at the offshore site. Since this specialized equipment operates deep beneath the sea surface, the step-down transformer must be capable also of operating at similar depths.

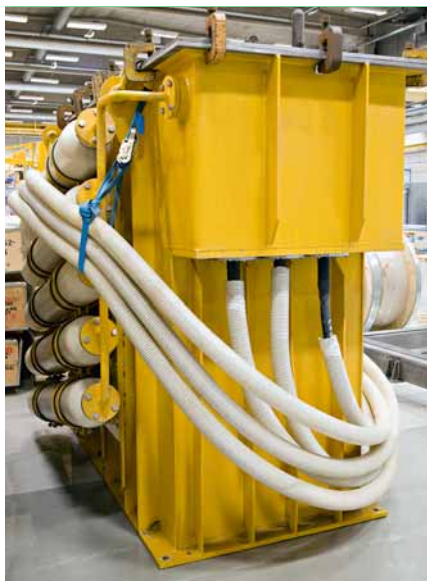
ABB has been developing subsea transformers since 1985. The first two subsea transformers, rated at 1.6MVA (megavolt amperes) 11 kV /1 kV, were submerged in 1999 to a depth of 500 m and have remained reliable to-date, powering oil booster pumps for the last 10 years. Since then ABB has been incrementally developing larger units. These transformers require specialized design features that enable them to operate at depth, under pressure. This has meant that all air and

gas-filled vaults within the outer casing must be eliminated by immersing components in liquid and developing a pressure compensating system to keep the internal pressure close to the outside water pressure. Since transformers get hot when operated, the type of liquid used inside the transformer is critical to its successful operation. High-class insulating oil with a low expansion coefficient that is compatible with the other material and components of the transformer was used. Such oil is degassed prior to installation since the transformer is housed in a solid tank, which cannot expand, even when hot. The heat generated by the transformer during operation has the potential to accelerate chemical reactions, possibly enhancing the corrosive effects of seawater and since the transformer is cooled by natural convection, has the

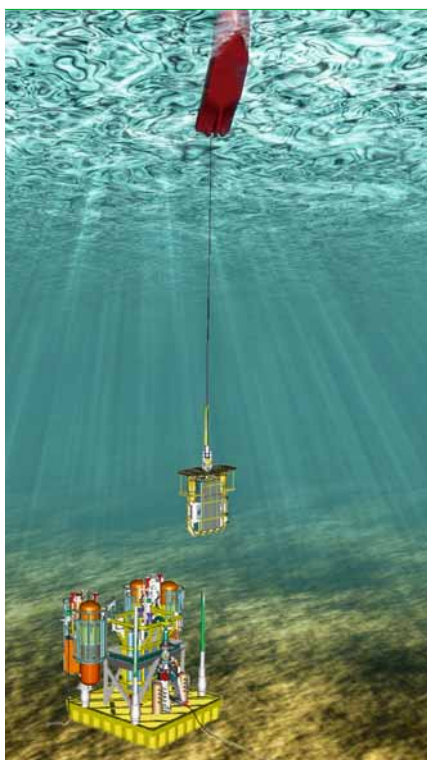
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potential also to attract living organisms to the outer surface of the casing. These factors have dictated the use of special high-grade steel for the casing, which is also especially able to cope with the high pressures associated with deep-sea locations. Such subsea transformers are about 2.5 m tall, 3.5 m long and 1.2 m wide and contain a volume of insulating oil of about 4 m³ **1**. When combined with

1 Subsea transformer



2 Installing a subsea transformer



the pump, valves and piping the entire unit can weigh about 20 to 50 metric tons, which would likely sink into the mud or sand if it were simply lowered to the seabed. This entire structure is mounted, therefore, on strong piles, which are first hammered into the seabed. Tubes on the underside of the structure slot over the piles so that the structure stands a few meters above the seabed when properly installed. Once installed no further maintenance or repairs are required. In fact, since the scope for doing repairs is limited, due to the expense of raising equipment to the surface, ABB has invested a great deal of time and effort to ensure all components are of the highest quality and have undergone rigorous testing. These stringent tests have ensured that all 15 subsea transformers currently installed are operating reliably and safely, providing great performance and cost benefits to offshore developments.

ABB's newest subsea transformer is rugged, powerful and capable of operating at depths of up to three kilometers.

Pipeline heaters

In the Gulf of Mexico, for example, at a depth of about 2,000 m the oil pipeline must be warmed to de-solidify oil, which due to pressure and cold, has frozen.

A mobile plant is transported by boat to the place where the pipeline is frozen. The mobile plant consists of an electrical system, a subsea cable and a subsea skid. The subsea skid, which includes a subsea transformer and the electrical connectors required to contact the pipeline, is lowered to the seabed **2**. With the help of a ROV (remotely operated vehicle) the electrical connectors are attached to the pipeline and the power is switched on.

The ship's diesel generator produces 480 volts and a step-up transformer is used to raise and regulate the voltage between 1 kV and 11 kV. At the seabed, the subsea transformer lowers

the voltage to a suitable level for the pipeline. The pipeline is then heated up and usually after a few days the blockage dissolves.

Highly rated

The most recent subsea transformer technology will ensure continuous production in a gas field located 400 meters under water off the coast of Norway. At the Norway site, building a new offshore platform near the gas field was considered too costly. Moreover, the field is 150 km from land, and 50 km from the nearest offshore platform. At these distances using conventional transmission voltages (6.6 kV) most of the power required to keep the compressor motors running on the seafloor would be lost. Instead ABB's newest subsea transformer is rugged, powerful and capable of operating at depths of up to three kilometers. With the highest power and voltage ratings (rated at 15 MVA / 50 kV / 6.6 kV) and the highest operating frequency (200 Hz), ABB's subsea transformer is the most efficient on the market and capable of reliable operation at this site.

The oil and gas industry constantly present new challenges as fresh fields are discovered for extraction. As a result ABB is already building even higher rated subsea transformers for 20 MVA 132 kV / 22.5 kV and 16.5 MVA 22 kV / 3.5 kV / 2.8 kV (title picture) that will be delivered in time to test equipment for the world's largest gas field, Ormen Lange, in Norway.

ABB remains the world's only manufacturer of subsea transformers capable of delivering reliable power underwater with minimal losses.

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Unlocking stranded information

The ABB WirelessHART™ upgrade adapter
Gareth Johnston

In today's economic climate, maximizing plant assets and reducing unplanned plant shutdowns has become a focus for reducing costs and maximizing productivity. Currently, potentially valuable information acquired by process instruments is often left stranded in the field. This information could be monitored if a communications pathway back to the host control system were created. Typically existing instruments have a built-in HART communication protocol, used normally during instrument commissioning. The arrival of wireless standards, such as WirelessHART™, has allowed ABB to develop an upgrade wireless adapter, which can be fitted to existing HART instruments, providing a cost-effective and secure communication pathway back to remote condition monitoring applications, such as ABB's Asset Vision Professional.



Innovation in production

The HART (Highway Addressable Remote Transducer) communication protocol is used by process instruments to digitally communicate process measurements and diagnostic information to intelligent hosts such as a distributed control system (DCS) or a HART handheld tool. The HART digital protocol is implemented as a frequency shift-key (FSK) that is superimposed on top of a 4 to 20 mA signal. Wired HART devices can connect with 4 to 20 mA analog I/O modules as part of a control system, which may or may not be able to communicate via HART. Today, HART is the dominant instrument communications protocol, with some 30 million 4 to 20 mA HART instruments installed worldwide. Its dominance is partially due to its ability to coexist with the 4 to 20 mA signal. Its position as market leader has remained despite the arrival of more sophisticated digital-only buses, which are often perceived as complex **1**.

Valuable information stranded
HART communication is often used during the commissioning of field instruments; typically a HART handheld tool is connected directly to the field instrument where parameters such as range and transducer type can be set. Once the handheld tool is disconnected, all the remaining instrument information is left stranded within the instrument unless a pathway back to the host is available.

It has been estimated that only 10 percent of the 30 million HART instruments installed since 1989 have a pathway back to the host.¹⁾ This remote access would allow operations and maintenance to take full advantage of this stranded instrument information for functions that include:

Process monitoring

Some instruments such as flow meters often measure

other process data such as totalizers, density or temperature, all of which are useful for process monitoring.

Condition monitoring

Process connection issues (eg, plugged impulse-line detection for differential pressure flow or control valve condition monitoring by signature analysis) and instrument issues (eg, analyzer consumable usage or analyzer probe condition) allow the condition of a process to be monitored.

Configuration database

This database is used to manage instrument configuration and maintenance checking.

The value of the information stranded within the instrument will largely depend upon the asset it is measuring or controlling and also upon the capabilities of the instrument itself. Some analyzers, for example, contain buffer fluids to allow periodic calibration; these buffer tanks will need refilling and this requires a maintenance alert.

Other plant assets with moving components (eg, drives or valves) would also have the ability to predict maintenance requirements based upon activity **2**.

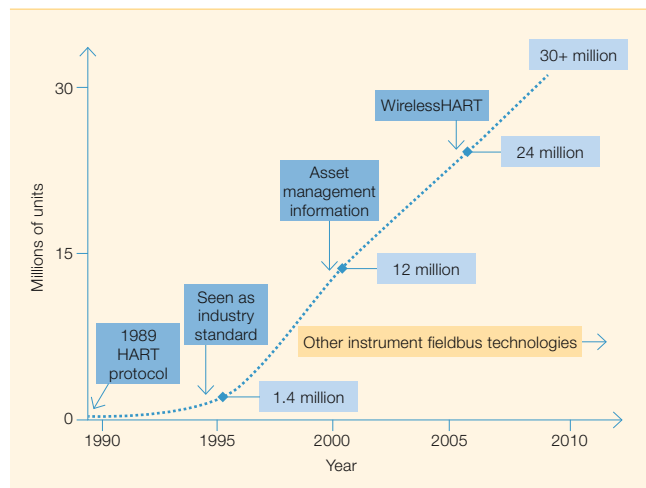
With industries struggling to cope with the current economic downturn, attention is focused upon the timely maintenance of assets in the field. Methods must be found by which to unlock the information stranded within instruments in an economical and low-risk way to maximize plant availability.

It has been estimated that only 10 percent of the 30 million HART instruments installed since 1989 have a pathway back to the host.

Unlocking the information

A traditional 4 to 20 mA control system would contain a programmable logic controller (PLC) with I/O modules wired through a marshalling cabinet via multi-core cable to the field **3**. The marshalling cabinet would contain

1 Growth of HART and major milestones



2 Example of detectable conditions for control valve positioner



Identified maintenance conditions monitored by the ABB valve positioner (part identification TZIDC)

Footnote

¹⁾ It is estimated that 75 percent of intelligent instruments use HART – 90 percent of these do not have remote access.

relevant power supplies and barriers or isolators. Access to HART data can be achieved by retrofitting a HART multiplexing unit with a serial link to the host system. The best location for the multiplexer would be in the marshalling cabinet where each instrument signal would be connected in turn.

The addition of a HART multiplexer to an existing installation is possible; however, there are issues to be aware of, eg:

- The most recent panel wiring diagram should be correct and available.
- Adequate space should be available in the marshalling cabinet.
- During installation each loop should be opened to connect to the multiplexer.
- It may be necessary to wait for a plant to shutdown.

Another option would be to add a wireless network to transmit the HART information from each instrument back to the host system for appropriate monitoring. A wireless adapter would be added to each instrument so that valuable information could be passed on **4**. The adapter could be powered via the 4 to 20 mA loop or via another source (eg, battery, local power, solar). Such a solution would provide a low-cost point-by-point addition of instruments to a wireless network, communicating back to an asset management system such as the ABB Asset Vision Professional (AVP).

A wireless adapter would be added to each instrument so that information could be passed on to an asset management system such as the ABB Asset Vision Professional.

The addition of remote access point-by-point is cost effective with phased installation, and there is no need for rewiring of marshalling cabinets or reliance upon wiring diagrams, providing lower-risk installation.

So shall we use WiFi?

Using an existing wireless network such as WiFi sounds like the best way

to proceed; however, with a little thought it is clear that such a solution has too many problems. WiFi is a good solution for transferring large files, networking PC's and peripherals in an office or at home, but industry requirements are much more vigorous and are particularly vulnerable to security and reliability issues **5**.

- Is WiFi secure enough?
- Can WiFi coexist with other wireless networks?
- Can WiFi adapt to changing environments?
- Will I need new tools to support it?

Often people's experience of WiFi is frustrating, especially when other networks are nearby. On an industrial site we know that the radio environment will change often (sometimes daily) as vehicles move through the plant or the infrastructure changes (eg, erecting scaffolding, adding new equipment). The conclusion is that to simply send HART over wireless (WiFi) does not provide an industrial-strength solution.²⁾

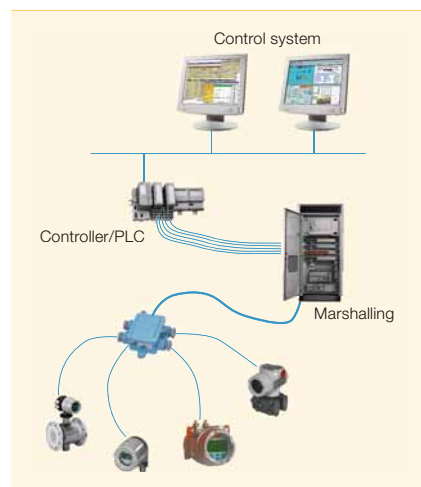
WirelessHART is the next evolutionary step for HART as the industry standard.

WirelessHART™ provides the solution by building in multiple levels of security, data authentication and redundant pathways back to the host. These functions are built in to the standard so that compliant devices can exchange data in a reliable and secure way through a WirelessHART network. Building a wireless solution upon HART is also cost effective as the engineering tools remain unchanged; you need only update the HART DD (device description) / DTM (device type manager) for the new devices.

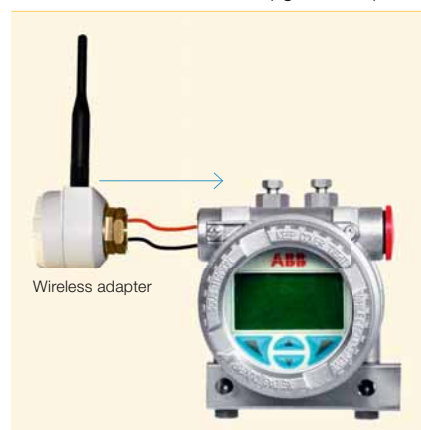
WirelessHART™ for instrumentation

The process industry is conservative and reliant upon standards, which provides lower costs and increased choice. Vendors such as ABB also prefer working with standards and so it is not surprising that WirelessHART has become the first such standard available. WirelessHART is the next evolu-

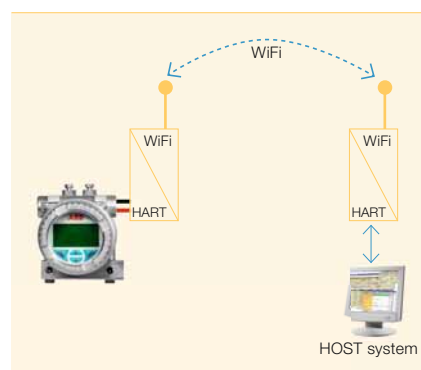
3 Traditional wired control system



4 The ABB WirelessHART upgrade adapter



5 HART over wireless – unsecured and unreliable



Footnotes

²⁾ Top three end-user requirements:

- Make it secure
- Make it reliable
- Keep it simple

³⁾ HART 7 is the most recent version of the HART specification and is fully backward compatible with existing HART instruments and tools. HART 7 includes additional features to support wireless networking.

Innovation in production

tionary step for HART as the industry standard and is part of the HART 7 specification³⁾.

The WirelessHART network is shown in 6. Little has changed for the host system since the HART communications is already built in. There is a high-speed fieldbus backbone to WirelessHART gateways located in the field. The WirelessHART gateway is responsible for building and grooming the wireless mesh, which connects the instruments to the network. A traditional HART handheld tool is used to join new WirelessHART instruments to the network 6. Joining requires entering a join key (encryption key) and network identification. The most secure way to enter these parameters is through a short physical connection via the handheld device.

WirelessHART has several strategies to satisfy the end-user requirements for security, reliability and simplicity. ABB is applying the WirelessHART specification to its instrument range where these strategies are built in.

WirelessHART is intrinsically compatible with the 30 million 4 to 20 mA HART instruments already installed – to use WirelessHART, simply apply a loop-powered plug-in upgrade adapter and use the same traditional HART tools with an updated DD or DTM.

Reliability

WirelessHART-enabled devices use a mesh network where alternate routes to get the information back to the gateway and the host system are available. If one pathway back is broken then an alternative path is selected automatically.

When coexisting with other neighboring networks the WirelessHART employs the following strategies to make

sure it gets the message through with minimal effect on other networks using similar frequency channels:

Channel hopping

Each message automatically uses a different frequency channel from the previous message to avoid other networks (there are 15 channels from which to select) 7.

Channel assessment

The transmission channel selected is tested to see if other networks are using

it before the data is sent (ie, avoids data collisions).

Short messages

The WirelessHART message is very short (3 to 4 ms in one 10 ms time slot).

Security

For WirelessHART devices security is built in and cannot be disabled 8. The main concerns are with data privacy and authentication. A brief view of the features built into WirelessHART, which are used by ABB in its WirelessHART instruments:

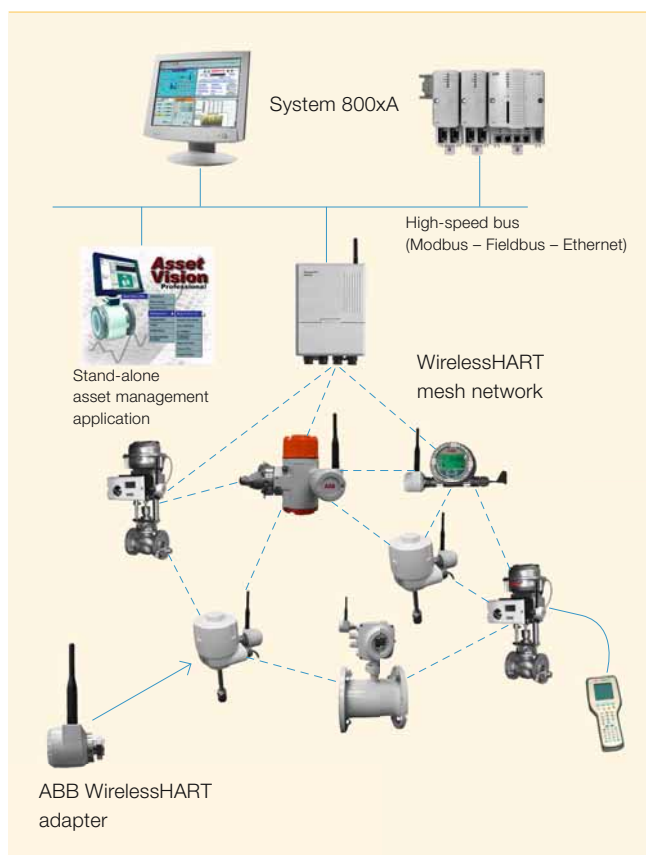
- Data is encrypted with a different encryption key as it hops through the mesh network, providing greater security.
- Data is authenticated to ensure it has not been altered by other agents as it passes through the network.
- Devices are authenticated as they join the network to prevent rogue devices joining.
- Messages are kept short and transmitted on different channels at each hop so that data is hard to find.

ABB has identified an urgent need to train potential users and provides support to the HART Communication Foundation (HCF) to create and run a series of worldwide technical road shows.⁴⁾

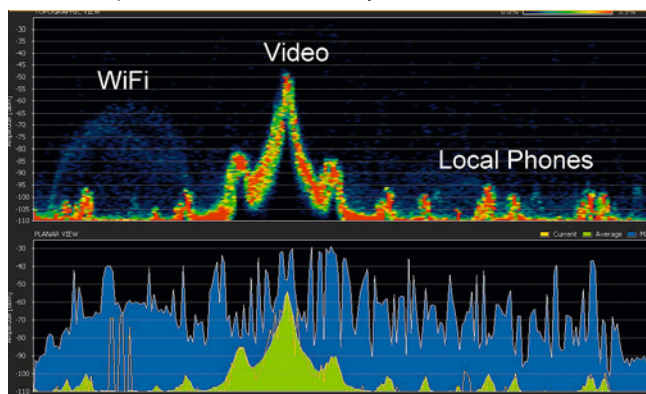
WirelessHART adapter

The upgrade adapter (NHU200-WL) will be the first ABB WirelessHART device available. This device allows operations and maintenance teams to unlock stranded information 9. The adapter is designed for ease

6 WirelessHART network



7 An example of on-site wireless activity



Footnote

- ⁴⁾ To find out when the next road show will be in your area, go to www.abb.com/instrumentation, register and follow Wireless Instrumentation links on the right.

of use during both installation and operation. This has been achieved by its small size and use of green power (energy scavenging), which means there are no batteries to maintain or replace.

Commissioning adapters

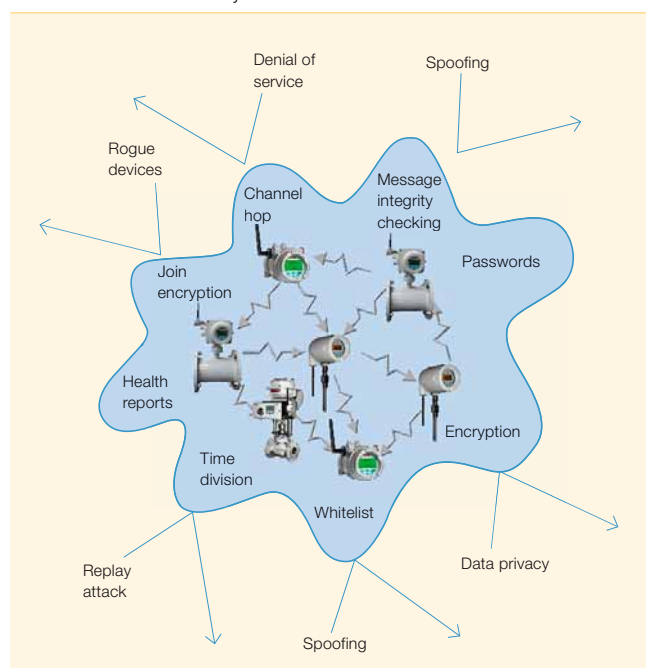
The adapter can be connected anywhere within the 4 to 20 mA loop used by the instrument. Typically this will be via a spare cable entry gland on the instrument or a T-piece, should only one gland be available. The small size of the adapter makes it easy to fit if there are obstructions nearby, ie, pneumatic connections to valves; in fact the antenna can be removed to make physical installation even easier.

- Connect the adapter in series with the target instrument.
- Connect a traditional HART tool (handheld or Asset Vision) to the

Factbox 1 Adapter benefits

- Small size makes it easy to fit in challenging conditions
- Rotating housing allows you to obtain the best antenna direction thus simplifying installation
- Green energy means there is no battery to maintain, reducing operating costs
- Low power requirements allow the adapter to be installed at the end of long cable runs increasing its suitability
- WirelessHART built in allows the adapter to join existing WirelessHART networks with other third-party vendor equipment, reducing costs and increasing flexibility
- Provides access to all the information (process data and maintenance information) in an existing installed 4 to 20 mA instrument
- When coupled with AVP (or other asset management applications) the adapter provides full remote access to instrument information (process and maintenance)
- Designed for use with ABB and other instruments

8 WirelessHART security



4 to 20 mA loop and set the joining parameters of the adapter (join key – network ID).

- Monitor the join status and disconnect the HART tool when complete.

The adapter will now read information from the target instrument and make it available to the host system.

Using the adapter

The main use of the adapter is in conjunction with asset management tools, such as ABB AVP to monitor instrument maintenance conditions ^{Footnote 1}. AVP has built-in asset monitors for HART instruments. These are used to check instrument maintenance conditions and provide additional information to assist with fault finding. These asset monitors can be used without modification with the WirelessHART adapter.

ABB's WirelessHART adapter is designed for ease of use during both installation and operation.

Once installed the adapter will route requests for information from the asset management system to the target instrument and then send back the reply ¹⁰.

WirelessHART tests

WirelessHART devices such as the ABB adapter will be part of a networked system so it is important that all devices are tested to comply with the written HCF specification. All ABB WirelessHART devices will be certified to work in multi-vendor networks with built-in features for reliability and security.

The HCF test kit used to certify WirelessHART devices became available mid-2009, which means certified devices are not expected to be available until the beginning of 2010, since it will take time to test and solve any problems found.

Trial site – BASF

BASF has joined together with NAMUR⁵⁾ to ask if WirelessHART provides the single standard for wireless process measurement and control devices. To gather information and answer this question, BASF Ludwigshafen in Germany was chosen as the trial site to install and test several WirelessHART networks with devices from multiple vendors, including ABB.

The trial at BASF started in July 2009 with precertified and prototype devices from ABB, Emerson, Endress & Hauser, MacTek, Pepperl & Fuchs and

9 ABB NHU200-WL WirelessHART upgrade adapter

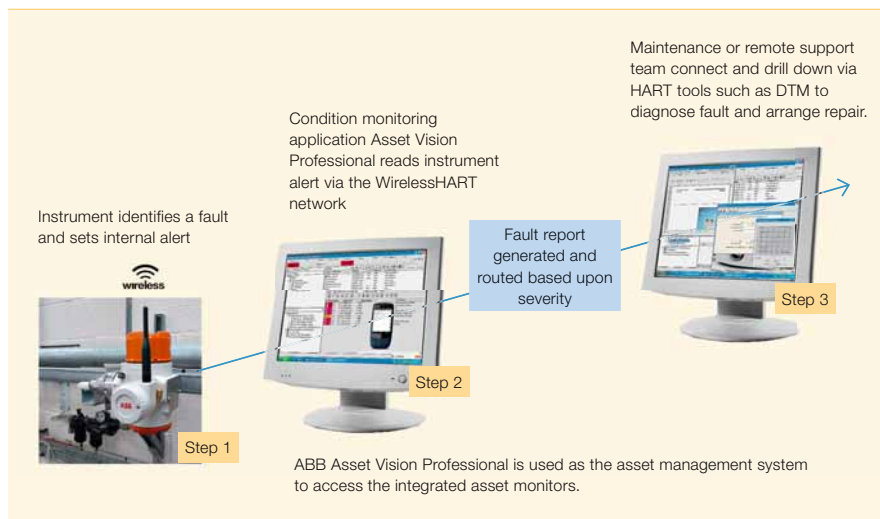


Footnote

⁵⁾ An international user association of automation technology in process industries

Innovation in production

10 Information flow between the adapter and the asset management system



Siemens. These were connected to host systems from ABB and Emerson. NAMUR has produced recommendation NE124 entitled "Requirements for Wireless Automation," which will form a basis for some of the testing. ABB has assisted with site installation and commissioning **Factbox 2**.

The trial has two phases.

Phase 1: The laboratory test focuses on interoperability, usability and response times. Other tests will include

Factbox 2 ABB Wireless Service

- Site assessment identifies potential site wireless issues and design solutions
- Installation and planning guidance
- Local support provides site visits and maintenance checking
- Remote support for distant locations surveys instrument maintenance conditions and advises about the action to take

Adapter installed on-site



coexistence with other radio standards such as 802.11b/g/n (used for example with WiFi).

Phase 2: Application tests focus upon installation and operational performance at several production plants at BASF's Ludwigshafen site. This phase will serve to validate the laboratory phase.

WirelessHART has been developed to complement wired networks for situations where installation is difficult and costs are high or when a second maintenance network is beneficial.

The results of these tests will be available during the fourth quarter of 2009.

In this context the NAMUR study represents a catalyst for both manufacturers and standardization bodies to prepare the ground for a joint and unique IEC standard for wireless sensor networks. Such a uniform wireless standard will help manufacturers and end users implement wireless applications quickly to harness the potential of this new technology.

The NAMUR technological study is not limited to the WirelessHART standard. The intention is to counteract the

emerging competition between the different standards at an early stage and to combine the advantages of the current WirelessHART and ISA SP100 initiatives.

Let's use wireless everywhere!

Wireless at the instrument level is not intended to replace wired 4 to 20 mA or any other digital-only fieldbuses. WirelessHART has been developed to complement wired networks for situations where installation is difficult and costs are high or when a second maintenance network is beneficial. ABB continues to monitor the development in wireless standards and will provide products based upon market demands.

This article has dealt with the case for wireless adapter use, where existing instruments are upgraded by the addition of a wireless network for condition monitoring or process monitoring in some cases. Wireless-only devices (battery powered instruments with only wireless connectivity) would be the subject of another article; however, the performance of such devices and wireless networks falls short of the requirements for critical process control and interlocking.⁶⁾ Wireless-only instruments (battery powered) would have an energy budget to deal with and so process refresh rates (although variable) are usually in the range of 30 s or several minutes.

Wireless for instrumentation has its place alongside wired versions and should be considered with care and perhaps supported by vendors such as ABB and the trial site reports of NAMUR or HCF.

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Footnote

⁶⁾ This is where a process value is used as part of a control sequence.

Innovation in action

ABB's ground breaking optical caliper sensor means papermakers can measure and control caliper on the most demanding paper grades

Rambod Naimohasses, Anthony Byatt



Papermakers have long sought a caliper sensor for their paper manufacturing machines that is accurate, reliable and does not mark or break the sheet. ABB has now launched such a sensor, which has proven to be far superior to other optically based caliper sensors. Initial customer feedback tells of reduced energy and raw material usage, and improved quality. Furthermore, the radical technology approach taken provides an interesting case study of innovation in action.

Innovation in production

One could be forgiven for thinking that paper, invented thousands of years ago, is one of the simplest products in the world to manufacture. Yet the modern production of even one sheet of photocopy paper involves an almost unimaginable array of technology – especially where the quality control system (QCS) on the papermaking machine is concerned. ABB is one of the top providers of such QCS technology to papermakers.

Central to a papermaker's operation is a scanning platform through which the paper web passes. This scanner holds an assembly of sensors that measure the principal properties – moisture and weight – of the paper as they move across the sheet. A sophisticated set of control algorithms then generates instructions for the paper-making machine to regulate the process.

Along with moisture and weight, accurate caliper (ie, the thickness of the paper) measurement and control are critical for defining paper. However, reliable caliper measurement has proven elusive.

The modern production of just one sheet of photocopy paper involves an almost unimaginable array of technology.

Past imperfect

Traditionally, accurate caliper measurement has been achieved using dual-sided contacting caliper sensors, the current industry standard. These run small “skis” over the paper and record the thickness change to within a 1 µm accuracy. Even though paper may look flat, on a microscopic level many paper grades actually look more like a mountain range! The caliper, by definition, is the paper thickness when some of the “peaks” have been lightly compressed and it is a need-to-have measurement for almost every papermaker.

Some types of paper present tremendous challenges for these contacting skis, and paper sheet damage, inaccurate

rate measurement and poor control can often result. This prompted ABB to pioneer non-contacting air-bearing sensors in the late 1960s. These offered simplicity but had marginal accuracy and resolution performance on high-speed machines.

More recently, QCS suppliers have focused on optical caliper sensors, usually utilizing the laser triangulation technique. This method has shown promise but is plagued by substantial errors caused by instability in a fast moving sheet, tilt effects from a non-flat sheet, sensor alignment, surface topography effects, and not least, laser light penetration into the semi-translucent paper body.

ABB has chosen quite a different, non-laser optical approach, one that provides greatly improved measurement accuracy and stability. This new sensor, the latest in its 50-year history of pioneering online paper quality measurements, finally provides papermakers with a precision tool to measure and control caliper on even the most demanding paper grades.

Laser triangulation limitations

Laser triangulation has found acceptance in industries such as metals, rubber and plastics. It compares a physical gap and a laser triangulation distance measurement to the free sheet surface. Triangulation works by focusing a laser beam onto the paper and following the position of the reflected light **1a**. The distance from the sheet surface can then be determined by analyzing where this image is formed.

Triangulation works extremely well for surfaces that have no penetration issues, such as metals. However, if the light penetrates into the bulk material, as can be the case with paper, then the method will have difficulties determining the true surface location and hence give a false distance measurement **1b**. Grade and process-dependent calibrations or other compensation may also be required as well. Some laser sensors may also need to operate in tandem with a periodically engaged contacting caliper sensor to refresh the laser sensor for both absolute and profile shape calibration.

Light penetration can be easily demonstrated by measuring five different paper-grade sheets – taped together – using a dual-sided contacting versus a dual-sided laser triangulation caliper sensor **2**. The agreement on the fine paper grades ranges from approximately 1 µm to about 10 µm. Often, the quality specification of these paper grades calls for a caliper variation of no greater than ±1 µm, so such variations in agreement can pose real problems as grades are changed on a single machine, or even as process conditions change. In addition, there are enormous discrepancies when paper grades change more extensively, such as the 30 to 50 µm offsets recorded for the card stock and kraft grades, for example.

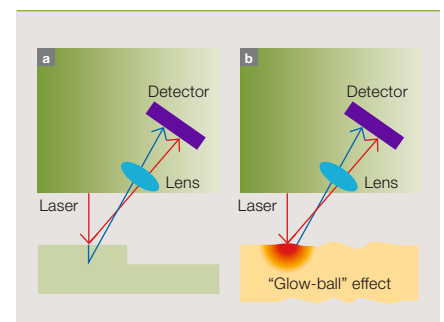
Along with moisture and weight, accurate caliper measurement, which has often proven elusive, is critical for defining paper.

On some thin paper grades, laser sensor caliper errors can approach 50 percent of the sheet thickness.¹⁾ To compensate, time-consuming fiber and filler-dependent calibrations have to be made.

Seeking a better method

Efforts to overcome many of these problems yielded only limited success.

1 Laser triangulation principle: The position of the reflected light changes as the sheet thickness varies **1a**. In **1b**, the glow-ball effect causes measurement uncertainty in some paper grades



Footnote

¹⁾ All these issues have been verified by other researchers [1,2,3].

However, because customer demand for a laser-based system was so high, ABB decided to embark on its own laser sensor development project.

Using its in-depth knowledge of light scattering from paper, ABB quickly concluded that even an enhanced laser triangulation technique was not the best tool for precision caliper measurement. A parallel study carried out to investigate the potential of technologies from other industries uncovered one technique that attracted much attention – an optical confocal displacement technique.

ABB's non-laser optical approach provides paper-makers with a precision tool to measure and control caliper on even the most demanding paper grades.

An initial evaluation showed it had the required micrometer resolution and other performance parameters. Its ability to measure rough paper surfaces on a dirty, humid and vibrating paper machine, however, was unknown as it had only ever been used in a stable laboratory environment. Laboratory tests finally proved that technology was indeed robust enough and it became the focus of the development project.

Optical principle

The confocal method works by projecting a small spot of broadband light ($12\mu\text{m}$) from a high-power white LED source, via fiber optics and through a lens system, onto the sheet surface ³. The lens system is designed to provide a high level of chromatic aberration, ie, the light is split into its component colors as it passes through the lens system. Each individual color is positioned at various distances from the lens. The reflected light from the sheet of paper is returned via the projected light path, ie, through the lens and the optical fiber. This shared optical path is one of the features that makes this a more accurate method than laser triangulation.

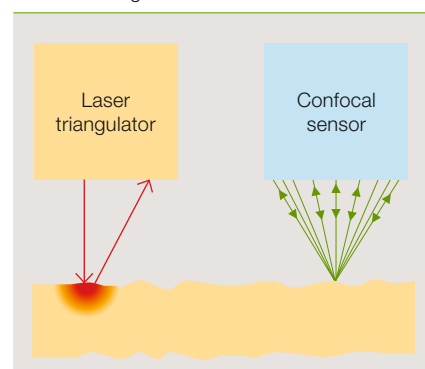
The variance in the height of paper surfaces is measured using wavelengths. To begin with, the various peaks present on the paper surface will pass through the focal point of a specific color. For example, when the paper surface passes through the focal point of the green light, then green light becomes the dominant wavelength received by the spectrometer detector. Special algorithms in the detector correlate this dominant reflected wavelength to the distance to the paper surface; a dedicated digital signal processor evaluates the received spectra at 4,000 measurements per second ⁴. A large numerical aperture ensures that dust in the beam path does not influence the measurement. An advantage of using wave-

length to measure distance is that it is unaffected by slight changes in the intensity of reflected light caused by paper color and brightness.

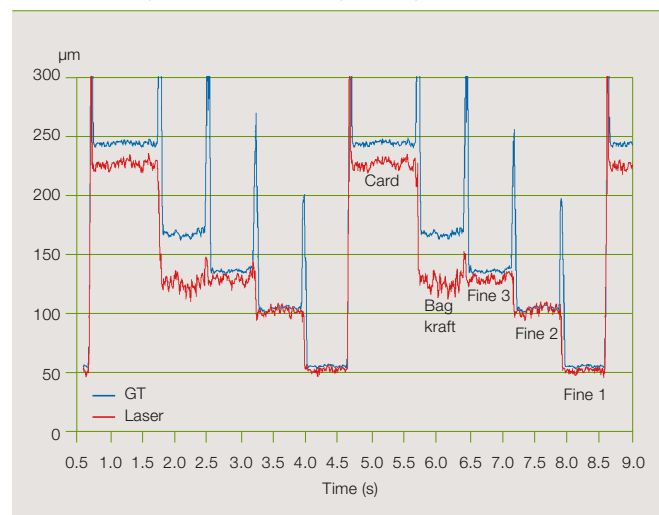
The confocal optical caliper sensor uses wavelengths to measure the height variations of paper surfaces.

A special spectral shape analysis algorithm further improves the agreement between sensor and laboratory, even for sheets with pronounced surface topography. This algorithm simulates the slight compression of the peaks that would be observed when measuring caliper on an offline laboratory instrument.

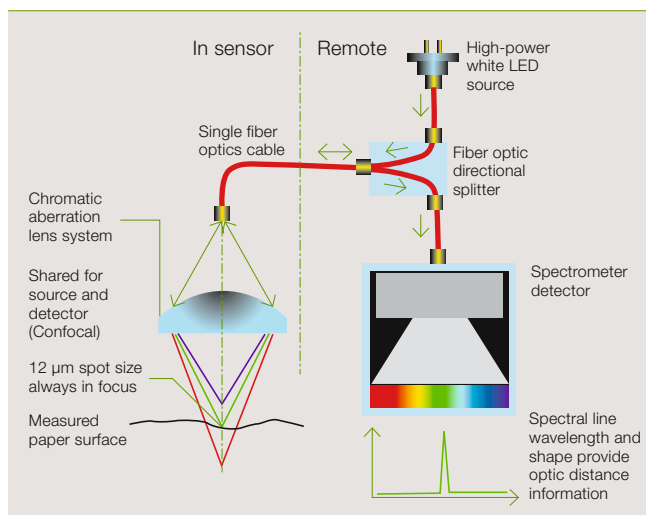
³ A confocal sensor vastly reduces errors from light penetration that may occur with laser triangulation



² The performance of laser triangulation versus contacting caliper (GT) on card, bag and three fine writing paper grades



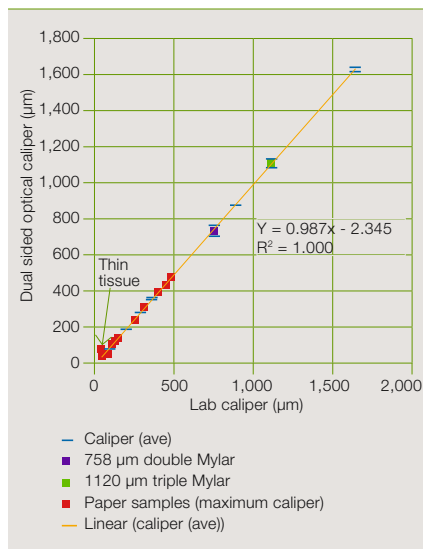
⁴ Confocal optical caliper sensor principle



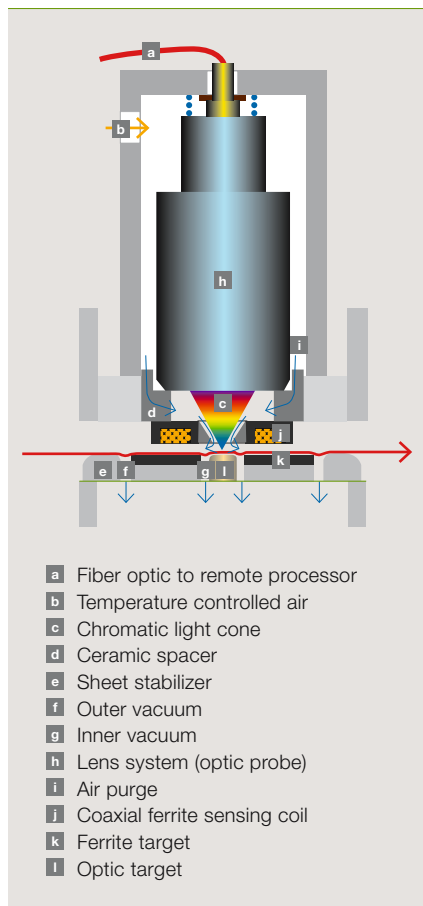
Innovation in production

The sensor output for a variety of demanding paper grades and Mylar samples, all with the same calibration constants, is shown in 5.²⁾ The grades of the paper samples used included

5 Confocal sensor reading for a variety of sample types and thickness levels, with the same calibration



6 Simplified sensor cross section



tissue,³⁾ SC-A, coated, uncoated, linerboard, newsprint, card stock, and glossy calendered grades. The fascinating thing about the graph is that it is very linear over a wide range of samples, implying that the measurement does not require any grade-dependent calibration. In other words, ABB's optical caliper sensor is the only one on the market today that can measure caliper for all paper grades with only a single calibration!

Engineering confocal technology to accurately measure paper caliper online in the extremely hostile environment of a paper mill is a major breakthrough.

Engineering challenges

The underlying confocal technology described above is not new. The breakthrough, however, is being able to engineer it to accurately measure paper caliper online in the extremely hostile environment of a paper mill. Besides the hot, humid and dusty conditions and the fact that paper moves at motorway speeds, a paper machine vibrates at magnitudes several times greater than the actual paper thickness.

One of the critical challenges then was to keep the sheet stable while measuring the gap distance. This difference is the reference distance between the top and bottom halves of the sensor, one on each side of the paper sheet and 10 mm apart.

Air gap and sheet stabilization

An accurate measurement of the sensor air gap is just as important as the optical measurement. A cross-section through the two sensor heads is shown in 6. The reference distance between the top and bottom heads is sensed by a specially designed magnetic inductance technology, which has proven to be exceptionally accurate and stable. The difference between this primary magnetic gap measurement and the optical distance measurement determines the caliper measurement.

Furthermore, there is a secondary magnetic sensor for 3-axis head alignment diagnostics and compensation. This feature makes the mechanical setup both easy to use and robust for the customer and enhances profile accuracy by multi-axis residual error correction.

An accurately positioned and flattened sheet is also essential for any optical caliper measurement. This is achieved by a sheet stabilizer located in the head of one of the sensors. The stabi-

The unique aerodynamic design means that even after six months continuous running there is little dust build up inside the vacuum chambers



Factbox ABB QCS: a long pedigree in paper sensing

ABB QCS has a long and distinguished history. Formed just over 50 years ago in Ohio, one of its earliest achievements, a paper basis weight sensor, represented the first-ever commercial use of radio-activity. Ever since, ABB QCS has been responsible for one innovation after another in paper sensing and production control.

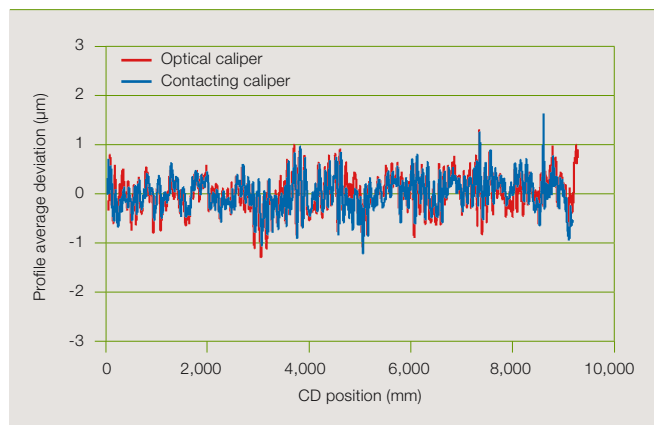
Today, the company helps papermakers sense and control their processes. As well as sensors (basis weight, moisture, fiber orientation, ash, and coating, all mounted on a steel scanning frame), other products include advanced control software and actuators.

Footnotes

²⁾ The test was performed in a lab environment and may not include all possible disturbances that can occur in a production environment.

³⁾ The reading from the thin tissue grade was higher than normal because unbounded individual fibers were physically extending outside the sheet boundaries.

7 Online performance on fully recycled newsprint grade



lizer contains a ferrite target for the primary magnetic gap measurement and an optical target onto which the optics are focused [4]. Sheet control is achieved by a very light vacuum, which gently smoothes the sheet and removes any wrinkles in the optical measurement zone without marking the sheet or allowing the buildup of coating or contaminants. As a result, the optical caliper sensor is applicable to demanding grades, such as newsprint, coated, super calendered, and fully-recycled grades.

The super smooth ceramic coatings and hard materials used in the sheet stabilizer plate prevent any buildup and sheet marking, and provide excellent wear resistance. The large vacuum zones are designed to prevent the accumulation of fillers and coating, thereby reducing or even eliminating the need for frequent maintenance cleaning.

Measurement results

The first test results taken from a real papermaking machine were exceptional. They were in agreement with a contacting caliper sensor installed in parallel, showing a deviation of less than $\pm 1 \mu\text{m}$. In addition, amazing small-scale variability became visible.

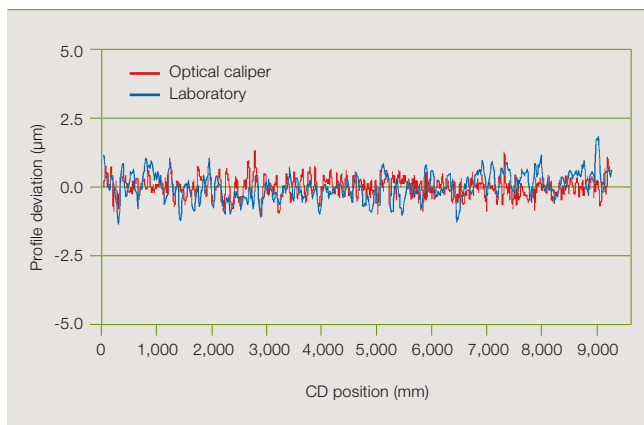
With ABB's optical caliper sensor, one customer has experienced a 55 percent drop in caliper-related poor quality costs.

The first permanent installation was on a large, 100 percent recycled furnished newsprint machine that produces a 9.3 meter wide sheet running at 1,700 m/min. This process can cause problems for contacting sensors, such as occasional buildup on the sensors or other mechanical factors

that may cause measurement degradation, or even sheet handling problems. The optical caliper was installed in December 2008 and has been used in the production process since January 2009. Just one month later it was used for live CD (cross direction) caliper control! Since then, the customer has reported improved reel building and a reduction in profile variation. Furthermore, the sensor requires little maintenance in this process – the sheet stabilizer plate is periodically cleaned only as a precaution.

The performance of the optical caliper is compared with that of the contacting caliper in 7. In this example, the profile deviation between contacting and optical measurement is better than $0.5 \mu\text{m}$. Sensor profile agreement with the customer's laboratory has also improved dramatically; the graph in 8 shows an agreement of better than $\pm 1 \mu\text{m}$.

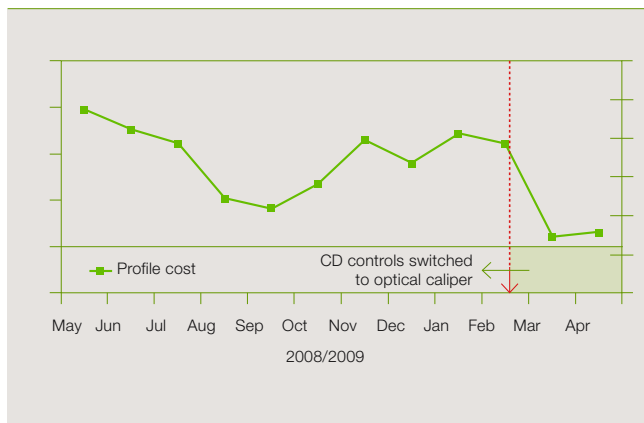
8 Optical caliper performance on 100 percent recycled newsprint



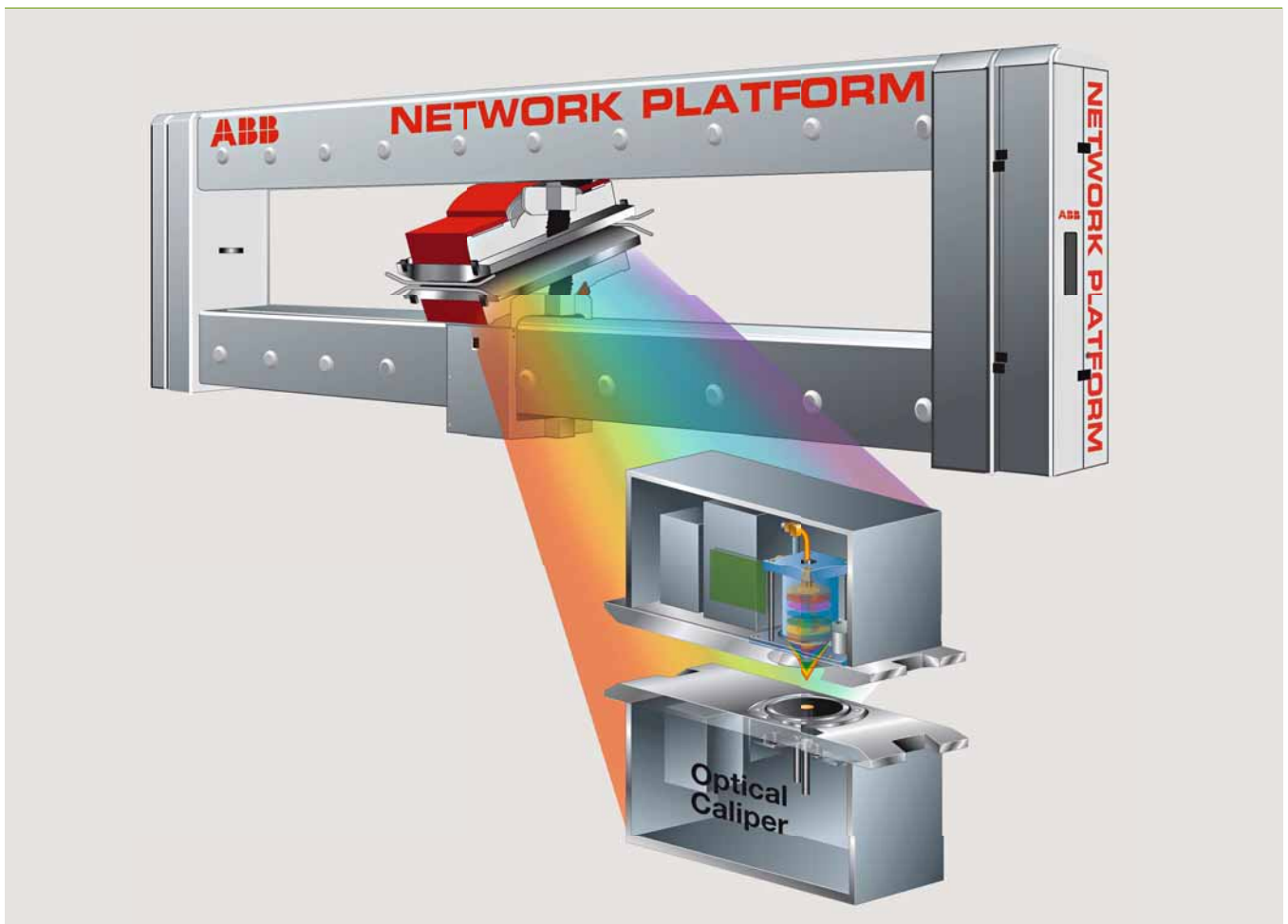
ABB's Network Platforms are the industry's strongest and smartest scanners, providing the process information necessary to optimize product quality.



9 Real mill data: The cost of poor caliper to the customer has more than halved since using the ABB optical caliper sensor to measure and control the customer's process.



ABB's Network Platform NP1200 equipped with the new optical caliper sensor



Customer benefits

The benefits to the customer are best described using real data from a real customer running one of the first optical caliper sensors [9]. The graph shows a 55 percent drop in caliper-related poor quality costs! Such a dramatic reduction in turn leads to significant savings in the amount of raw material needed, and the energy and chemicals used.

ABB's optical caliper controls the paper quality to within 1µm when several different grades are being manufactured, and it is not sensitive

to calender pressure, speed and tension profiles across the machine.

Papermakers can now buy a caliper sensor that is accurate, reliable and does not mark or break the sheet.

Stora Enso Eilenburg in Sachsen, Germany has reported it is "very satisfied" with ABB's optical caliper sensor. The company says the sensor "is working with CD caliper control" and that

there are "no problems on the paper edges and no waste paper on the winder."

Rambod Naimohasses

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- [3] Holik, H. (2006). Handbook of paper and board. (409) ISBN 3527309977.
- [4] US published patent applications 20090059244, 20090056156 and 20090059232; all titled "Web Measurement Device." USPTO, March 5, 2009.

Dexterous and articulate

ABB's new IRB 120 robot and IRC5 Compact controller

Pierre Mikaelsson, Mark Curtis

Many industries rely on robots to improve productivity, reliability and safety. They are primarily used for assembly, material handling and for the movement of products around the factory. Their ability to carry out highly repetitive tasks tirelessly and often in hazardous environments ensures greater product uniformity and helps to reduce employees' exposure to danger.

The brand new IRB 120 is the latest ABB robot and is ideally suited to a wide range of tasks, including the handling and assembly of small, delicate components. It is a compact desktop robot capable of manipulating payloads up to 3 kg.

ABB is a leading manufacturer of industrial robots and has played a significant role in promoting their use in manufacturing.



Innovation in production

In many industries, including pharmaceutical, medical, solar, electronics (particularly the 3C: computer, communication and consumer) industries, food and beverage industries and research sectors, the assembly and handling of products are labor intensive and the production pace is often high. Tedious or repetitive production tasks can result in fatigue, which may lead to production bottlenecks, repetitive strain injuries or other employee health issues. Furthermore, in countries like Japan, with falling populations, the size of the available workforce is also expected to fall, which may lead to inflated labor costs and possibly reduced manufacturing capacity.

After discussing the market requirements with over 50 system integrators, partners and end customers across the globe, ABB concluded that a cost-effective, compact, agile and lightweight robot was required to satisfy these industries' needs. ABB followed up by developing the IRB 120 to automate lightweight multicomponent manufacturing processes. The robot's accuracy and versatility ensures that product quality and uniformity are retained, while reducing production costs and providing greater flexibility, so that production capacity can be adjusted rapidly to meet changes in demand.

The IRB 120's multiple mounting options provide greater flexibility for the design of automated production lines, helping reduce the footprint required for production processes.

ABB's IRB 120 robot

The IRB 120 is ABB's smallest robot, offering all the functionality of the ABB range in a much smaller package. It has a single articulated arm with a reach of 580 mm, a distance

1 The IRB 120 can be mounted in a wide range of positions. Here, it is mounted from the ceiling (left) and a wall (right).



designed to mimic the reach of a human arm. Like all of ABB's single-arm robots, the IRB 120 is dexterous with six axes of movement **Factbox 1**. This feature, together with its compact turning radius (due to its symmetry when vertically extended), allows the robot to be mounted close to other equipment. The robot's multiple mounting options provide greater flexibility for the design of automated production lines and help to reduce the footprint required for production

2 The IRB 120 weighs in at 25 kg



processes **1**. Once installed, these robots can reach components 112 mm below their base and can operate in tight locations, thanks to their slim wrist, smooth and easy-to-clean surfaces, and internally routed cables. These features also make it ideally suited to applications in dust-free environments.

The IRB 120's light, yet robust aluminum structure and its powerful compact motors weigh in at just 25 kg **2**. This ensures that the robot is capable of rapid and accurate acceleration. In fact, the IRB 120 has all the fine features common to the ABB

robot tradition, including the best path accuracy and motion control on the market. With these features, manufacturers can be assured of high and consistent quality in production.

The IRB 120's light, yet robust aluminum structure and its powerful compact motors weigh in at just 25 kg.

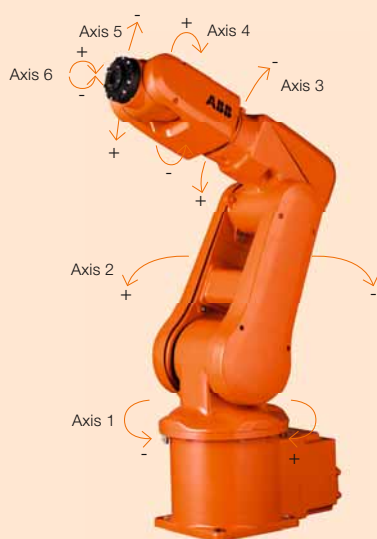
The IRC5 Compact controller

The IRB 120's high speed, smooth movements and accuracy are achieved using ABB's new lightweight (27.5 kg) IRC5 Compact controller, the latest addition to ABB's comprehensive IRC5 family of robot controllers **3**. This device delivers superior motion control and uses ABB's RAPID robot programming language. The program can be viewed and executed using either the Windows style FlexPendant™ HMI (human machine interface) **Factbox 2**, which was developed as an integral part of the IRC5 Compact controller, or using a PC. The controller supports structured programs, shop-floor language and many advanced process applications. Using advanced dynamic modeling, the controller can optimize the performance of the robot for the shortest possible cycle time and precise path accuracy, automatically delivering consistently high performance with no additional tuning required by

the programmer. Such features will be familiar to users of existing IRC5 controllers, requiring no additional training to operate the new compact version. In addition all benefits to users of the IRC5 controller are extended to the IRC5 Compact controller, such as

Factbox 1 Six axes of movement

The robot can rotate from left to right by 330 degrees through axis 1, close to the base plate. Immediately above this rotation point is axis 2, which allows the arm to pivot so that the upper arm can extend horizontally forward or backward. Axis 3 extends the robot's vertical reach so that the upper part of the arm can be raised and lowered. Axis 4 provides what is known as the wrist roll. It rotates the upper arm in a circular motion moving the end effector between the horizontal and vertical orientations. Axis 5 is responsible for the pitch, giving up and down motion, and the yaw, giving left and right motion. Finally axis 6 provides a twisting motion, giving the effector more than 360 degrees of rotation in either a clockwise or counterclockwise direction.



3 The IRC5 Compact controller



worldwide dedicated support and the global availability of quality spare parts.

ABB's new lightweight IRC5 Compact controller provides high speed, smooth movements and accuracy to the IRB 120 robot.

The combined weight of the IRB 120, its IRC5 Compact controller, floor cables and FlexPendant is less than 60kg, providing a truly compact, lightweight robotic system.

In addition the new IRC5 Compact controller enables easy commissioning through one-phase power input, external connectors for all signals and a built-in expandable 16 in, 16 out I/O system. Sensor interface functionality, remote disk access and socket messaging are examples of the many powerful networking features available to operators. Remote monitoring of the robot is also available through standard communication networks such as GSM¹⁾ or Ethernet. Advanced diagnostic methods allow fast investigation of failure as well as the monitoring of the robot's condition throughout its life cycle. Service packages are also available, including new

Factbox 2 The FlexPendant

When using the FlexPendant, the operator can take advantage of several design features that make robot control easy. Firstly, it is a complete computer in itself and is therefore unaffected by controller load. It can be used easily by both right- and left-handed operators. It is characterized by its clean, color graphical touch-screen design and 3-D joystick for intuitive interaction. Powerful customized application support enables loading of tailor-made applications, for example customized operator screens, which eliminate the need for any separate additional operator HMI. It features enhanced language support, including Asian characters, so that operators around the world can work in their own languages.

services such as program backup management, reporting, and proactive maintenance activities.

Although initially released for the new IRB 120, the IRC5 Compact controller is also scheduled to be released throughout 2010 for the operation of other small ABB robots.

Offline programming is also available for the IRB 120 through ABB's RobotStudioTM, which enables manufacturers to simulate a production cell to find the optimal position for the robot, and provide offline programming to prevent costly downtime and delays to production.

The combined weight of the IRB120, its IRC5 Compact controller, floor cables and FlexPendant is less than 60 kg, providing a truly compact, lightweight robotic system.

ABB has many years of experience in the automation business and is particularly well equipped to automate production processes. Improved cycle times, consistent high quality and increased flexibility have contributed to the success of many industries. With this in mind, ABB launches its new compact IRB 120 robot and IRC5 Compact controller. Together they will extend ABB's automation solutions to industries concerned with the assembly and handling of small, complex components and devices.

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The extended-reach robot

ABB's new IRB 2600

Per Löwgren

The industrial robot has at times been referred to as "the extended arm of man." Robots have extended human abilities by making productivity feasible in hazardous environments, or where levels of repeatability or throughput are required that humans cannot match. However, the "extended arm" additionally has a less metaphoric and more practical meaning. In many situations a robot's usefulness depends on its physical reach. For

example a workpiece need not be turned or repositioned if the robot can simply stretch over to a given point. Alternatively, in some situations one long-reach robot can do the work of two shorter-reach ones.

While the working range of a robot should be large, the space needed for the robot itself should be as small as possible. Ideally a robot should further reduce its space demands by

permitting mounting on shelves, walls or even on the ceiling.

ABB's new IRB 2600 – with its long reach yet compact construction and flexible mounting – fulfills all of these demands. Furthermore, it is the fastest, most accurate and best protected robot for the 12 to 20 kg payload range on the market.



The 20 kg payload range has a long history with ABB: It goes back 35 years to ABB's first-ever robot – the IRB6. The IRB 2600 represents the fourth generation of ABB robots to cover this category **Factbox**.

Features

The IRB 2600 comes in three variants **1**. Besides the basic variant, which has a payload of 12 kg and an arm reach of 1.65 m, the extended variants offer an increased payload of 20 kg or an increased reach of 1.85 m.

Working range and mounting options

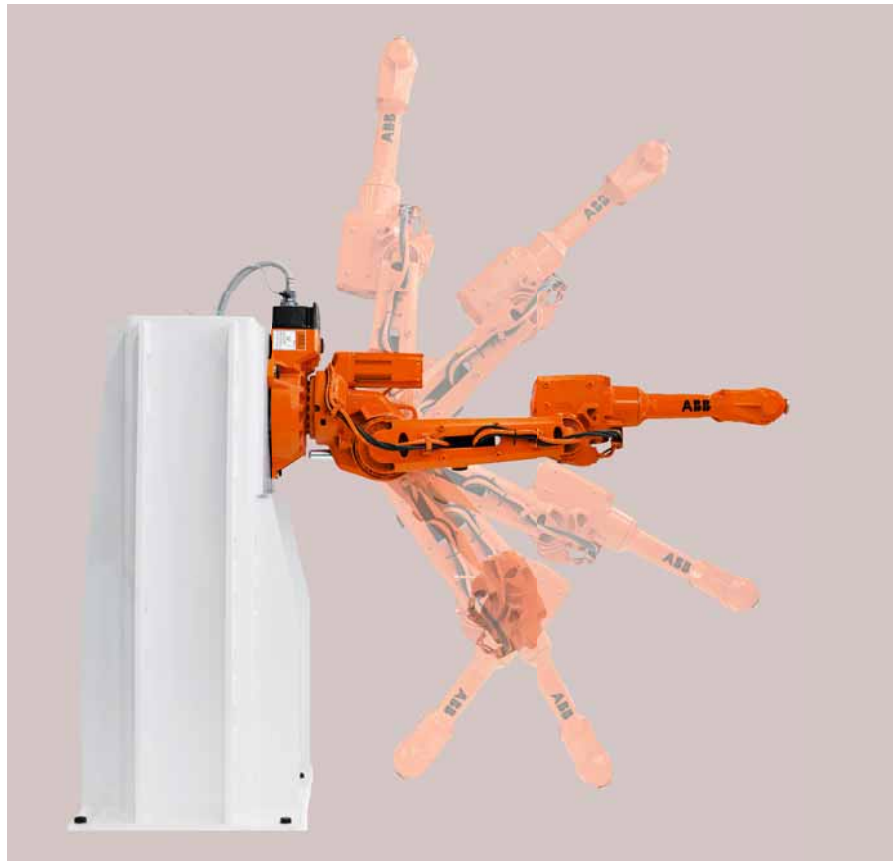
One factor setting shelf-mounted robots apart from strictly floor-mounted ones is the need for their working range to extend down below the robot's base plate. The full working range of the IRB 2600 is shown in **2**. Alternative mounting options (eg, floor, tilted and inverted¹⁾) are shown in **3**. The obvious advantage of such mounting options is the freeing up of floor space. Other advantages are that cycle times or working patterns can be improved through the optimization of the robot's placement, or that the installation of several robots at different heights in the same cell permits them to work on the same workpiece simultaneously.

Cycle times

The IRB 2600 offers up to 25 percent shorter cycle times than its immediate predecessor, the IRB 2400, and offers the highest accelerations available on the market. Contributing to this is a weight reduction from 380 to 280 kg

(compared with the IRB 2400) and ABB's advanced motion control technology.

ABB introduced the first version of its path accuracy functionality in 1993.



Footnote

¹⁾ Inverted mounting is available as an option.

1 The three variants of the IRB 2600:



The basic version IRB 2600-12/1.65



The IRB 2600-20/1.65 with an increased payload of 20 kg (instead of 12)



The IRB 2600-20/1.85 with an increased arm reach of 1.85 m (instead of 1.65)

Innovation in production

Path accuracy means that:

- The robot can be successfully deployed in applications where accurate paths are required by the process.
- The robot can easily be programmed to follow the path.
- The programmed path is correctly followed, with a very small tolerance and independently of speed.

The user only needs to enter the correct payload and armload data. Path accuracy was invented by ABB and is an illustration of the company's leadership in robotics motion-control technology.

Protection

Protection is an important element of many robot applications. Protection

can be about adequately protecting a robot from the hostile environment in which it is working, for example, moisture, corrosion or abrasive particles. It can also be about protecting the product being manufactured from possible contamination by the robot, for example flaking or droplets. As the IRB 2600 is targeted at a broad palette of applications ranging from extremely hostile environments such as foundries to extremely sensitive areas such as food handling or even electronics manufacturing in clean rooms, the robot comes with a variety of protection options tailored for the specific application.

One important protection aspect fulfilled by all IRB 2600 robots is that

they meet the IP67²⁾ ingress protection classification **4**.

In foundries, molten particles and water-borne release agents can cause degradation of the robot. Measures therefore include a rust-protected mounting flange and protection guards for cables **5** as well as specially resistant paints. Protection options for other environments include resilience to aggressive detergents, high pressures and high temperatures.

Connectivity

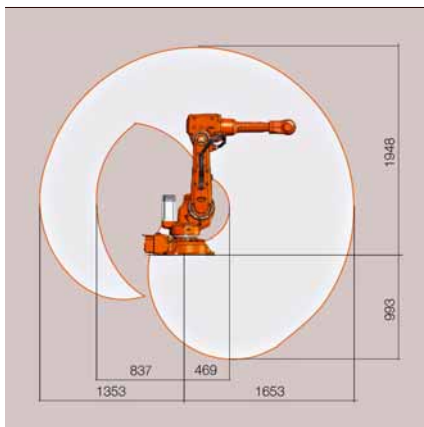
To be able to control complex process equipment, tooling, grippers, etc., the IRB 2600's upper arm integrates connectors for the PROFINET, EtherNet/IP and DeviceNet fieldbus standards. This simplifies cabling and interfaces and so contributes to increased reliability.

One factor setting shelf-mounted robots apart from strictly floor-mounted ones is the need for the working range to extend down below the robot's base plate.

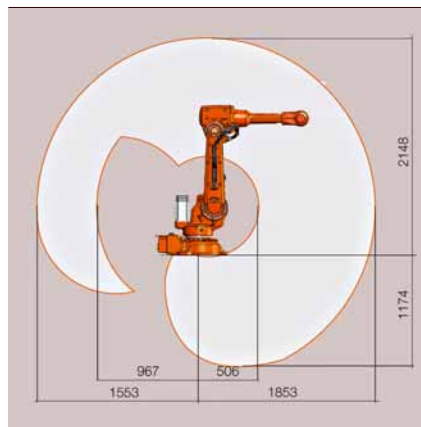
Electronic position switches

Sometimes it is necessary to limit the working range of a robot, for example for safety reasons or to avoid collisions with adjacent robots or other machinery. Usually this is achieved with electromechanical switches preventing axes from being turned beyond a given point. The IRB 2600 no longer requires these as this safety is assured through electronic position tracking and in coordination with ABB's SafeMove functionality³⁾. This means that no physical adjustments need to be made to the robot. The solution leads to faster commissioning

2 Working range of the IRB 2600



IRB 2600-12/1.65 and IRB 2600-20/1.65



IRB 2600-12/1.85

3 Mounting variants of the IRB 2600: floor **a**, shelf **b**, tilted **c**, wall **d** and inverted **e**



Footnotes

²⁾ The IP classification system expresses ingress protection using two figures. The first describes protection against solid particles and the second against liquids. IP67 states that the device is totally protected against dust (class 6) and that it is protected against the effects of immersion at depths of up to 1 m (class 7).

³⁾ See also "Taming the robot: Better safety without higher fences" in *ABB Review* 4/2006, pages 11–14.

times and simpler integration and is easier to set up, modify, replace and maintain. Most notably it does not compromise reliability when compared to the electromechanical switch solution.

Applications

Typical applications for the IRB 2600 include:

- Machine tending
- Material handling
- Arc welding
- Process applications

Machine tending

An example of a machine tending application is the extraction of plastic moldings from an injection-molding machine. Typically, the robot is mounted on a shelf **6** beside the machine, from where it must reach down below its own base to extract the workpiece. A large working range in the area below the robot's base is thus essential. The IRB 2600 can reach 993 mm below its shelf (1,174 mm in the case of the IRB 2600-12/1.85).

Furthermore, material handling cycles are often a significant factor limiting throughput and hence the productivity of injection-molding lines. The IRB 2600's short cycle times, enabled

by its high acceleration, make it well suited for such work.

Path accuracy means the controller takes the complete load case into account when directing the robot's movements – ABB was the first company to provide such functionality.

Material handling

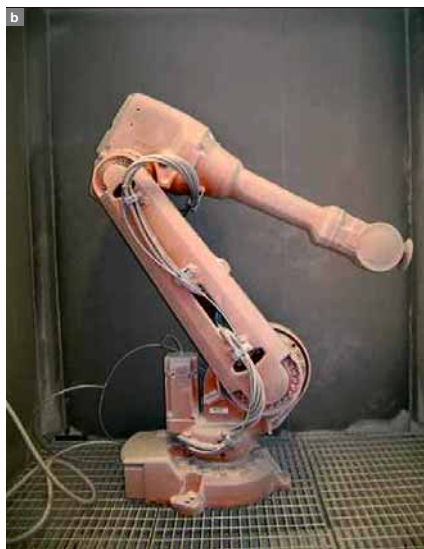
One area of application at which the IRB 2600 is targeted is the manufacturing of photovoltaic panels. The combined effects of environmental awareness, concerns over carbon dependency, government-backed incentives and the resulting advances in technology and economies of scale are leading to a rapid growth in photovoltaics.⁴⁾ With photovoltaic electricity moving toward price parity (the point at which its production costs equal those of conventional sources) and large photovoltaic arrays being planned in areas with high levels of insolation, the demand for photovoltaic cells will continue to see

elevated growth rates. Among the tendencies in the photovoltaics market is the demand for larger panels. The IRB 2600 is well suited for this as its working range permits it to manufac-

- 5** Cable protection for hostile environments such as foundries



- 4** Meeting the IP67 ingress protection standard. Submerged in water **a** and resisting dust **b**. The robot in **b** is painted orange like the others illustrated in this article, but this is hard to recognize under the dust.



- 6** The IRB 2600 can reach far below its base, making it suited for shelf mounting.



Footnote

⁴⁾ For more information on ABB's activities in the photovoltaics sector, see "From light to power" on pages 22–24 of this edition of *ABB Review*. For a broader look at ABB and solar energy, see also "New power under the sun" on pages 16–21.

Innovation in production

ture large panels (6 x 12)⁵⁾. Its suitability for such work is further enhanced by its clean-room compliance (up to ISO 14644-1 class 5⁶⁾) and its compact design, which minimizes floor space.

Further material handling applications can be found in the food and beverage industry, for example packaging bread. In such an application the robot is typically wall mounted.

Arc welding

The high accuracy and repeatability of the IRB 2600's movements combined with its short cycle times are among the factors that make this robot highly suited for arc welding applications.

Process applications

Process applications for which the IRB 2600 is suitable include:

- Water-jet cutting
- Laser cutting
- Routing⁷⁾
- Dispensing⁸⁾
- Material removal

To be able to control complex process equipment, tooling, grippers, etc., the IRB 2600's upper arm integrates connectors for the PROFINET, EtherNet/IP and DeviceNet fieldbus standards.

A truly versatile robot

Through its extended working range yet limited space requirements, the IRB 2600 is a flexible workhorse that can fulfill the demands of many industries. Its limited space requirements are further enhanced by its flexibility in mounting solutions, permitting such variants as shelf, wall, incline or inverse mounting contributing to both space saving and flexibility in deployment. The robot's high acceleration and shortened cycle times means it can furthermore boost the productivity and throughput of many production lines. These advantages are further enhanced by its attractive protection solutions and control and connectivity options. The IRB 2600 is a robot that can truly reach out further to meet the application's needs.

For more information on ABB and robotics, please visit www.abb.com/robotics.

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Factbox Four generations of robots

ASEA (one of ABB's predecessor companies) launched its first robot, the IRB6, in 1974. This robot was a milestone in many respects: Not only was it the world's first fully electric industrial robot (earlier types had been hydraulic), but it was also the first microprocessor-controlled robot. In fact it represented the first industrial application of any microprocessor (the processor used was Intel's 8008, a chip that was pivotal in starting the microcomputer revolution and that was a direct predecessor of the later and better-known 8080). A further significant feature of the IRB6 was its anthropomorphic arm configuration. The IRB6 had a

payload capacity of 6 kg and was used in a variety of applications ranging from handling to welding and deburring.

ASEA (from 1988 ABB) continued to offer the IRB6 until 1991, with about 7,000 units being made.

The IRB 2600 is ABB's fourth robot generation in the 6 to 20 kg payload class. Like its ancestor, the IRB 2600 is setting a benchmark: It is the fastest, longest reaching, most accurate and best protected 20 kg-range robot on the market.



1st generation
1974
IRB 6



2nd generation
1986
IRB 2000



3rd generation
1996
IRB 2400



4th generation
2009
IRB 2600

**Footnotes**

⁵⁾ With individual cells typically being 125 x 125 mm, and adding cell spacing, a 6 x 12 panel can have dimensions of 810 x 1580 mm.

⁶⁾ ISO class 5 indicates less than 100,000 particles greater than 0.1 µm in 1 m³ of air. For class 6 the figure is 1,000,000 particles.

⁷⁾ Routing: cutting plastics with a rotating file

⁸⁾ Dispensing: applying material to a surface, eg gluing or sealing

Refined integration

State-of-the art electrical integration for a refinery
utilizing System 800xA and IEC 61850

Antonio Carvalho, Johan Hansson

A reliable and dependable energy supply is vital for the functioning of any industry. Managing and controlling this supply is thus as important as managing and controlling any other significant process parameter. The integration of the electrical control system into the process control system increases productivity and availability by permitting a single strategy in the areas of engineering, maintenance and operations.

ABB has taken the lead in the domain of electrical integration with its award-winning Extended Automation System 800xA, enabling intelligent electrical devices to be integrated utilizing the global IEC 61850 standard for control and protection of substation equipment. The adoption of a global standard based on state-of-the-art technology enables lower installation and operational costs, as well as enhanced asset management capabilities.

ABB is providing process control and power management systems based on System 800xA to nine of Petrobras's 12 Brazilian refineries – solutions that will help increase production by a massive 40 percent. In this article, *ABB Review* takes a look at the project in Petrobras' REPAR refinery.

Innovation in production

Electrical integration is not a new concept. Low-, medium- and high-voltage devices have been integrated into process control systems (PCSs) for many years. Traditionally, the systems that serve process automation and power distribution within the same plant are separate, but are coupled by extensive hardwired interfaces. Due to cabling and engineering costs, the bandwidth and cost efficiency of this approach is very limited. The introduction of intelligent electrical devices (IEDs) and serial interfaces permitted much more information from the electrical system to be utilized. This approach is commonly used today in industrial and power generation applications.

A large variety of protocols and standards are used in substation automation, including IEC60870-5-10x, DNP 3.0, Modbus and various legacy protocols. The multitude of interfaces required lead to a broad variety of engineering tools, protocol converters and gateways, and hence additional hardware, maintenance and increased engineering costs. This could result in solutions having to be implemented on a project-by-project or even a device-by-device basis. **1** illustrates a scenario that has different serial protocols for communication with the IEDs, as well as a hardwired interface between the electrical and process control system.

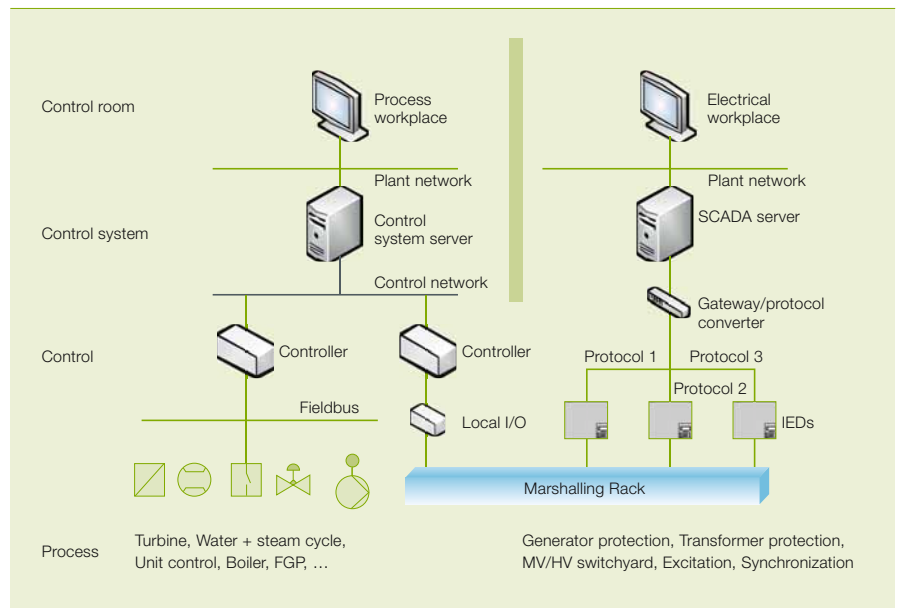
IEC 61850

The 2004 introduction of the global IEC 61850 standard for substation automation represented a huge step forward in simplifying the integration of IEDs. The standard ensures the interoperability between devices and is capable of replacing all the various protocols in the substation-automation domain.

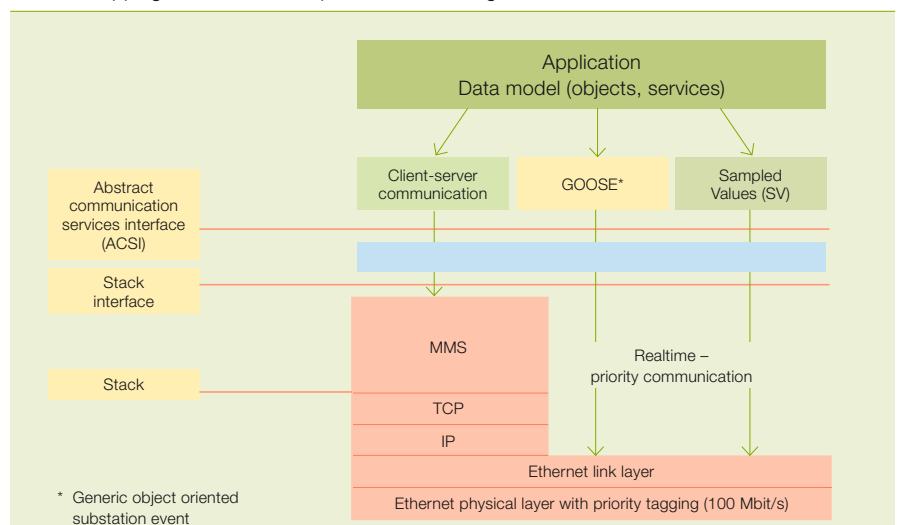
At the core of the IEC 61850 standard is a complete object-oriented model of the IED, its data and supported communication services. These are modeled in a form that is consistent across all types and brands of IEC 61850 compliant IEDs. Interoperability is further supported by the use of a common XML-based substation configuration description language (SCL)

Factbox 1.

1 Separate process and power automation systems using hardwired integration



Factbox 1 Mapping of data model to protocols according to the IEC 61850 standard



IEC 61850 communication

IEC 61850 uses mainstream communication technology MMS (Manufacturing Message Specification) over TCP/IP and Ethernet. The data model and the communication stack are linked by means of standardized mapping. This mapping is the only item that needs adaptation should the communication technology be changed. Such an approach ensures long-term stability in the face of future developments. The adopted mapping from communication services to the communication stack is shown in the adjoining figure. Client-server communication (vertical communication from the IEDs to the control system) uses a

mapping from the data model to the full MMS stack (left-hand side of figure). GOOSE (Generic Object-Oriented Substation Event) and Sampled Values (SV) are further communication services, both used for real-time high-priority data – achieved by direct mappings into the Ethernet link layer and eliminating any middle-layer processing. GOOSE is used for horizontal communication between IEDs, where it replaces the traditionally hardwired signals. Sampled values are used for sending currents and voltage measurements in a high-priority fashion, mostly used in high-voltage applications.

IEC 61850's integration in System 800xA

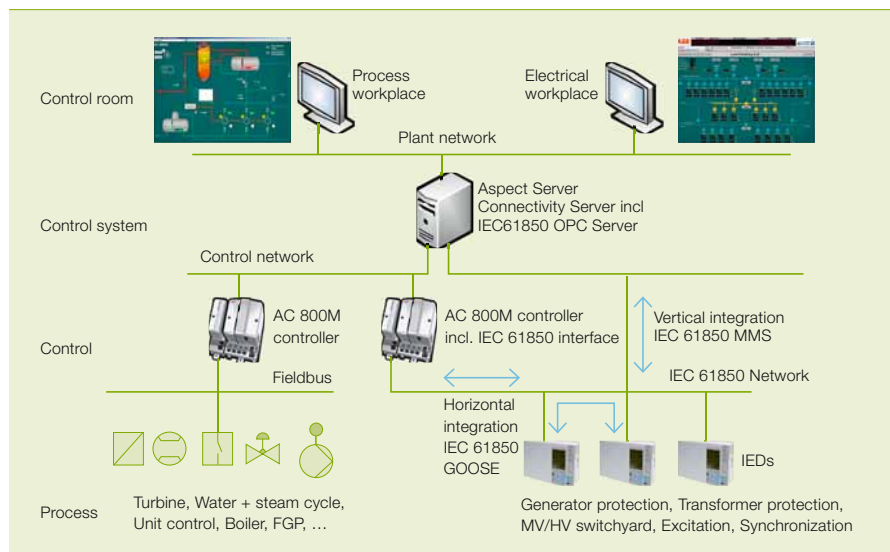
ABB's System 800xA is the first process-control system on the market to support the IEC 61850 standard. The implementation is shown in [2]. Both vertical communication (using the full MMS stack) and horizontal communication (using GOOSE¹⁾) are supported.

The vertical integration is implemented using an IEC 61850 OPC server²⁾, which transfers the MMS data to System 800xA in the form of regular OPC data items. This means System 800xA has direct access to all selected IED data such as current and voltage measurements, status, interlocking, time-stamped alarms and events, and can also send open and close commands to the IEDs. All System 800xA display capabilities, such as freely configurable graphics, faceplates, alarms and event lists, and historian capabilities are available. Furthermore, IED parameter reading and writing can be performed remotely, as can the transfer of disturbance recording files to System 800xA.

The horizontal part of the integration is achieved with the AC 800M controller utilizing GOOSE communication. By equipping the AC 800M with an IEC 61850 interface, horizontal communication is made possible with all other IEDs on the same IEC 61850 network in a real-time fashion. Examples of application areas are fast load-shedding signals, interlocking, or even analog values needed in the controller application.

By utilizing both vertical and horizontal communication, System 800xA is equipped to use the latest state-of-the-art technology to communicate with IEDs according to a global standard. This means seamless integration of substation equipment, enabling true integrated process and power automation with a single-system solution. The main benefits are:

2 Integrated process and power automation using System 800xA with IEC 61850



Factbox 2 What is power management?

The supply of power and energy is vital to every industry. The management of that supply is just as important. Industry's dependence on scarce energy resources, the volatility of energy costs, growing environmental concerns and more stringent legislation are just a few of the factors influencing the global drive for improved energy management.

Power management has been designed specifically for the most energy-intensive sectors in which industries operate, such as in oil and gas and petrochemicals. In many areas around the world, operations face an insufficient or unreliable public power supply. Such industries must therefore largely depend on their own generation and distribution capabilities. Power management schemes manage energy vulnerability and ensure sustainable energy for plant operations by reconciling efficiency, economic, health, safety and environmental considerations.

The power management system controls and supervises power generation and supply. One of the most important functions is load shedding, which requires fast network determination and energy balance calculations. The protection/control units can also monitor and, if necessary, invoke frequency-based load shedding. Another important function in power management is generator

control (including integration with the governor and excitation controller).

ABB's Power Management System (PMS), an offering based on System 800xA meets the requirements of industries in which power management is a vital topic in terms of costs and an important prerequisite for reliable operation.

ABB's System 800xA PMS is a state-of-the-art solution with advanced features that surpass the capabilities of traditional automation systems. These include:

- Extensive scalability in size, performance and functionality
- Redundancy at all levels
- Support of multiple programming languages
- Support of legacy, standard and ongoing developments in the area of communication protocols, including OPC, Modbus, Modbus TCP, PROFIBUS DP, Profinet, TCP/IP, IEC 60870, DNP3, IEC 61850 and others
- High-speed communication capabilities
- Support of IEC 61131-3 programming languages
- Integration with process control systems
- Integration with subordinate systems, including GPS, meteorological stations and motor control centers and CMMS
- Asset optimization
- Extended security and access control

Footnotes

¹⁾ GOOSE: Generic Object-Oriented Substation Event

²⁾ OPC is a standard for real-time communication between control devices from different manufacturers. Today, OPC is officially a name and not an acronym, but originally stood for OLE for Process Control.

OLE stands for Object Linking and Embedding, a document embedding and linking technology.

Innovation in production

- One user interface ensures consistency in data presentation, data access and operating procedures – meaning a significant improvement in operator effectiveness
- Data recording and archiving onto one single database for faster error analysis and capturing plant-wide sequence of events
- Lower cost of ownership due to fewer spare parts, and less training, system administration and documentation being required
- Enhanced asset-management capabilities using the electrical diagnostic data and connection to enterprise level systems such as computerized maintenance management systems (CMMS)

The REPAR refinery is one of Petrobras' most important downstream production units.

Power management for Petrobras

ABB has a large installed base of power management systems **Factbox 2** in Petrobras refineries **Factbox 3**. Of the 12 refineries owned by Petrobras on Brazilian territory, ABB has installed the PMS in nine of them and the process control system in seven.

Three years ago, as part of their strategic growth plan, Petrobras decided to invest in increasing its production and in improving the quality of its products – mainly in the areas of diesel and gasoline – through the addition of new production units and the modernization of others in existing refineries. In February 2008, Petrobras thus signed a frame agreement with ABB for the supply of PMS and PCS. The agreement had a value of \$61 million and covered the supply of hardware, software and technical services including specialized training. The contract forecast implementation of around 70 projects on nine refineries in which ABB has installed base.

The scale of the modernization program is immense. In addition to building new units for hydro treatment, cooking, desulfurization and other processes, Petrobras is constructing 50 new substations and modernizing

about 40 others using the IEC 61850 standard.

ABB's System 800xA is ideally suited for such large-scale plant-wide projects: In addition to being the leading automation platform in a wide range of process industries, it has the unique capability to integrate the process, electrical and safety systems into a single system.

This, among other things, enables refinery operators to monitor and control the systems from a single interface and run power management applications and intelligent IEC 61850 substations in the process-control system.

The operational and cost benefits of such an integrated system are huge, including optimization of all automation and electrical assets, simplified engineering, streamlined maintenance, improved energy efficiency, and lower initial investment costs compared with running non-integrated systems.

Petrobras is planning to further streamline its processes in operation, maintenance, training, optimization and quality control. System 800xA can provide data and resources to support such improvements.

ABB's System 800xA is the first process-control system on the market to support the IEC 61850 standard.

REPAR Project

The REPAR refinery is one of Petrobras' most important downstream production units. It is located in Brazil's Parana state, one of the most industrialized and most populated regions of the country. Consequently, REPAR is among the refineries to receive a larger investment in the Petrobras strategic plan.

The implementation of the growth plan of the REPAR refinery included the installation of the new PMS. This encompassed several new substations including a 230 kV intake substation, a 69 kV GIS³⁾ distribution substation and 12 process substations as well as two

new turbo generators. The project almost tripled the energy available for the REPAR refinery from 26 MW to 76 MW and included the building of a new power house and 12 new substations and the modernization of eight existing substations.

The REPAR refinery adopted the IEC 61850 standard as the communi-

Factbox 3 Petrobras

Petrobras (short for Petróleo Brasileiro S.A.), is a semi-public Brazilian multinational energy company headquartered in Rio de Janeiro. In terms of market capitalization and revenue, it is the largest company in Latin America, and the largest company headquartered in the Southern Hemisphere. The company was founded in 1953, and while it ceased to be Brazil's legal monopolist in the oil industry in 1997, it remains a significant oil producer, with output of more than 2 million barrels of oil equivalent per day, as well as a major distributor of oil products. The company also owns oil refineries and oil tankers. Petrobras is a world leader in the development of advanced technology for deep-water and ultra-deep water oil production.

Today, Petrobras operates in 27 countries in the energy sector, primarily in the areas of exploration, production, refining, trading and transportation of oil and its derivatives in Brazil and abroad. Its current motto is "An integrated energy company that works with social and environmental responsibility." The company is fourth in the ranking of the largest publicly held oil from the world, is the third largest in the Americas in market value and occupies the sixth place among the world's largest companies in terms of market value.

Areas	Quantity
Market value – August/2009	\$ 173.59 billion
Service stations	More than 8,000
Employees – June/2009	75,242
Production platforms	112
Thermoelectric plants	10
Refineries	16
Average oil & natural gas production – June/2009	2,505,379 barrels/day
Total investments – 2009/2013	\$ 174.4 billion
Investment in biofuels – 2009/2013	\$ 2.8 billion

cation technology for its substation automation and PMS. ABB's System 800xA was ideally suited to meet REPAR's PMS needs. The new PMS was required to integrate the functionality of its predecessor system in terms of using the same database of key control features such as load-shedding responses and reactive-power control in a single and centralized solution. The old PMS thus saw its Advant stations upgraded to System 800xA, while retaining its Advant Master controllers. The new substations use System 800xA from the start ³.

The new substations use redundant AC800M controllers that have IEC 61850 interfaces and PROFIBUS DP fieldbus networks to connect to intelligent MCC⁴ and drives. The IEC 61850 network is used in the following voltage levels: 69.0 kV GIS substation, 13.8 kV switchgear, 2.4 kV medium-voltage distribution-center panels and 0.48 kV distribution-center panels. Thus ABB's PMS is used to control all voltage levels of the electrical system of the refinery. The operation of System 800xA is supported by ABB's PMS Library, whose implementation builds on 24 years of experience with power-management systems in ABB.

When this project is complete, System 800xA will have 16 redundantly fitted AC800M controllers installed in 10 substations interfacing with around 460 IEDs in total.

For the operation of the new PMS and PCS, REPAR built a new centralized control room where a total of 56 System 800xA operator stations are being installed. Four of them will be exclusively used for the monitoring of electrical operations. One of the most important projects was the 69 kV GIS, based on ABB's 670 series of IEDs – the substation is already working using the new technology.

The rigorous studies connected to the introduction of IEC 61850 network architecture **Factbox 4** brought automation engineers and substation engineers together to the same "project table." ABB is supporting the integration efforts by guiding substation engineers

in the correct usage of the IEC 61850 data model to permit a perfect integration with System 800xA PMS.

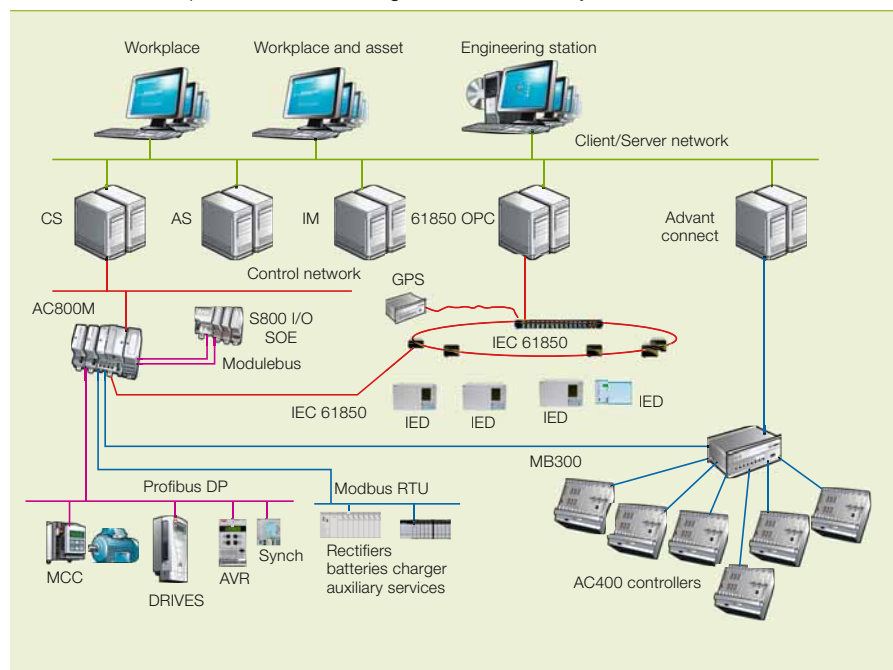
Benefits

Some of the benefits for Petrobras are:

Standardization

The adoption of IEC 61850 technology and System 800xA permitted Petrobras to standardize various procedures in substation configuration, control logic, control libraries and operation procedures. These translated into savings in commissioning time and configuration. The object orientation of IEC 61850 supports standardized device models using names instead of object/register numbers and indexes. System 800xA,

3 PMS REPAR simplified architecture integrated with existent system



Footnotes

³ GIS: gas-insulated switchgear

⁴ MCC: motor control center



Innovation in production

through its IEC 61850 compliance, was able to fully support this standardization.

Lower investment cost

The use of IEC 61850 combined with System 800xA PMS brought simplicity to many phases of the project implementation. This was noticed in the definition, design and engineering phases through the common user environment, use of the Ethernet standard, the single tool for the engineering integration of all devices, less wiring and more advanced protection capabilities thanks to the use of horizontal GOOSE messaging for direct exchange of data between devices.

Lower life-cycle costs

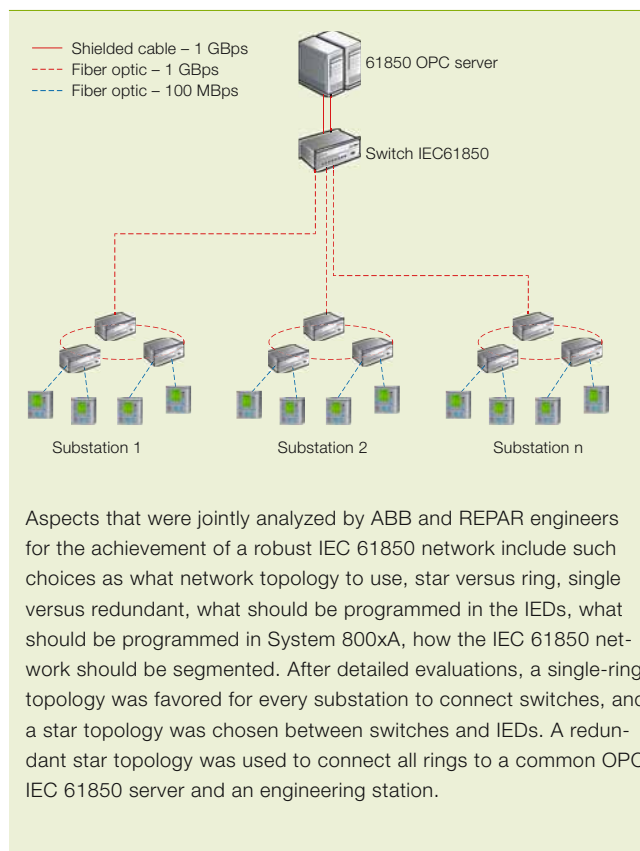
One of the main benefits delivered to REPAR was optimal life-cycle management and low life-cycle cost through the use of a future-proof system with IEC 61850 interoperability. The reuse of engineering data and the use of a standard language for programming highlighted the power of IEC 61850 for REPAR projects and the associated costs savings through less need for training and reduced staff requirements.

The adoption of System 800xA also protected past investments: The existing system, based on Advant Master controllers, could be fully integrated with the new. Furthermore, the new PMS has structures ready to receive a future replacement of the legacy system controllers.

Integrated process and power automation

A unified system for process and power automation was used to combine power management, process electrification and process control into a single control environment in the REPAR Refinery. Benefits that REPAR already valued with its existent PMS, such as reduced energy costs through power management, were transferred into the new system and strengthened through the implementation of a fully

Factbox 4 Architectural analysis



integrated system. The control of drives, intelligent MCC's, medium-voltage switchgear, protection and control IEDs were all integrated on the same system. Improvements directly perceivable by REPAR include increased visibility of the process, the possibility of asset management of electrical devices, improved interface with process control and improvements in operation procedures.

The adoption of System 800xA protected past investments: The existing system, based on Advant Mastercontrollers, could be fully integrated with the new.

Reliability and availability

System 800xA allows the implementation of a PMS in a DCS platform. The use of this platform gives the system the highest levels of availability and reliability. The REPAR Project is based on redundant AC800M controllers, a

redundant control network, a redundant IEC 61850 OPC interface, and other arrangements in which System 800xA was tailored to meet Petrobras specifications. This and other mechanisms of availability improvements helped deliver a system to REPAR that reduced unscheduled downtime.

A digital system integrated with a powerful IEC 61850 network allowed use of remote maintenance tools, access to device diagnostics and reporting, increasing system reliability.

A successful integration

ABB has recognized the implementation of an integrated process-control and power management system based on System 800xA for the Petrobras REPAR refinery as one of its top innovations of 2009.⁵⁾ The REPAR project will be completed in 2011, with the other Petrobras projects following later. The integration of PMS and PCS will enable higher productivity through more far-reaching optimization of plant operations and will represent a model for future projects worldwide.

The photographs used in this article are of the REPAR refinery and copyright of Petrobras.

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Footnote

⁵⁾ See "An innovative 2009" on page 6 of this edition of ABB Review

Cruise control

A propulsion condition management system that allows onshore monitoring of offshore installations

Jaroslav Nowak, Sami Kanerva

Keeping tight schedules is a fact of life for most cruiseship operators. Because speed and maneuverability are two important factors that help a ship's punctuality, ABB's Azipod® electric propulsion system is fast becoming the system of choice for many operators.

System reliability throughout the life of the vessel is also an important factor that could make or break operators. Knowing the condition of their assets at all times not only prevents the unexpected from happening but it also can help to improve long- and short-term efficiency and performance.

With the availability of new and improved service solutions, ABB is helping operators get the absolute most from their investment. Its new Propulsion Condition Management System (PCMS) is a fully scalable and flexible monitoring tool that is now used on one of the most state-of-the-art cruise liners ever built, Celebrity Solstice.



Innovation on the move

As the expression goes, “time is money,” and in an environment as cut-throat as today’s, tolerance of delays and downtime is quickly diminishing. Preparing for the unexpected is and should be an integral part of any organization’s effort to reduce risk. Instead of responding to particular events, companies need to focus on maintaining operations no matter what happens. This means implementing a strategy that not only manages risk but also brings other long-term benefits with strategic payoffs.

For cruiseship operators, staying on schedule is absolutely fundamental to their business. Even with the continuous improvements in ship design techniques and propulsion technology, operators can never give a cast-iron guarantee that nothing will go wrong. The best strategy, however, is to be prepared for most, if not all eventualities.

Ship designers today not only look at ways of increasing reliability but they also have to focus on energy efficiency, performance and the need to cut emissions.

Ship designers today not only look at ways of increasing reliability but they also have to focus on energy efficiency, performance and the need to cut emissions. Even though the term energy efficiency is usually associated with the reduction of energy needed to provide the same level of energy service, it also encompasses other attributes, such as proper maintenance, planned repairs and the maximum availability of technical equipment.

Recent studies made by Wärtsilä¹⁾ on boosting energy efficiency in ship applications have identified four areas with the potential for improvement: ship design, propulsion, machinery, and operation and maintenance [1].

ABB’s Azipod® is an example of an electric propulsion system that is well-known for its energy efficiency. Such is its reputation that 50 percent of all

cruise liners built during the last two decades have the Azipod electric propulsion system installed, and today an ever-increasing number of vessel types are being designed and built with it. It can reduce fuel consumption by up to 30 percent – when Dynamic Positioning (DP²⁾) a computer controlled system to automatically maintain a vessel’s position and heading by using its own propellers and thrusters – is included as part of a ship’s operation.

For a cruiseship operator, the availability of Azipod is extremely important. That is why ABB works hard to support the end customer with tools and services that not only ensure he is constantly aware of the condition of his asset but also that he is informed of the most optimal way of using it.

The latest addition to this portfolio of solutions is called the Propulsion Condition Management System (PCMS). It is a result of a two-part strategy that sets out to give the customer the best possible service both during the warranty period and after it has expired. PCMS was developed during the first part of this strategy, which involved developing a condition-monitoring system in a pluggable and scalable architecture that would collect and analyze process data from as many installed devices as possible. This data constructs a continuous image of the system performance, which can be remotely accessed by an ABB service engineer, thereby allowing him to plan and recommend improvements in the responsiveness and quality of the system with the customer.

The second step in the strategy involves the evaluation of service offerings for the customer after the warranty period has expired. It consists of a model that is comprised of different service-contract scenarios and options ranging from simple troubleshooting through periodic maintenance right up to continuous monitoring.

A pilot version of the PCMS was installed onboard the Celebrity Solstice cruise liner in October 2008. Constructed in the Meyer-Werft shipyard in Papenburg (Niedersachsen), Sol-

stice was, at that time, the biggest ship ever built in Germany.

Efficiency in motion

Celebrity Solstice (title picture) is designed to be the most energy-efficient cruise ship on the market; when compared with other ships, energy savings of approximately 30 percent have been achieved using high energy-efficient components, such as a photovoltaic system, optimized hydrodynamics, an extremely efficient underwater coating and an energy-saving lighting system using LEDs.

ABB’s new Propulsion Condition Management System (PCMS) is a fully scalable and flexible monitoring tool that collects and analyzes process data from many installed devices.

Power generation for all propulsion and electrical power needs onboard is satisfied using only four main diesel generators rather than the five or six required by other recent big cruise ships. The four Wärtsilä 16V46CR diesel engines, each rated at 16,800 kW at 514 rpm, are arranged in a power-plant configuration and give a total power output of 67,200 kW. Celebrity Solstice is the first cruise ship in the Royal Caribbean International, Celebrity Cruises fleet with common rail fuel injection **Factbox 1**.

Propulsion is provided by a pair of ABB V23-type Azipod units, each with a rated power output of 20.5 MW running at 137 rpm. Each five-bladed propeller has a diameter of 5.8 m and is interconnected with a synchronous and brushless 6-phase electric motor,

Footnotes

¹⁾ Wärtsilä is a Finnish manufacturer of large diesel and gas engines for use in powering ships and electricity generation.

²⁾ Position reference sensors, combined with wind sensors, motion sensors and gyro compasses provide information to the computer pertaining to the vessel’s position and the magnitude and direction of environmental forces affecting its position. DP is used extensively in the offshore oil industry.

Factbox 1 A common rail injection system

The way in which fuel is injected into the cylinders of diesel vehicles determines their torque, fuel consumption, emissions and noise level. Two factors are important for an efficient system: the fuel pressure as it enters the cylinder, and the shape and number of the injections.

A common rail injection system separates these two functions (generating pressure and injecting) by first storing fuel under high pressure in a central accumulator rail and then delivering it to the individual electronically controlled injection valves (injectors). This ensures that incredibly high injection pressures (in some cases over 25,000 psi or 1724 bar) are available at all times.

Source: <http://www.dieselforum.org>, retrieved September, 2009.

which is driven by two medium-voltage propulsion drives ACS 6000SD voltage source inverter (VSI) frequency converter) each rated at 10.5 MVA

Factbox 2

As well as focusing on efficiency, the ship's designers put a lot of effort into implementing sophisticated navigation systems. The latest version of NAPA Power, a system that finds the optimal way to operate the vessel by optimizing the route, speed profile and propulsion mode for each part of the voyage, is installed on the Celebrity Solstice. The system is based on a 3-D model of the ship and includes the latest research on the hydrodynamics affecting a ship's resistance. To properly estimate the ship's performance, the model requires an accurate representation of the power plant and propulsion system, and other parameters, such as sea currents, varying winds, waves and water depth also need to be taken into account [2].

the unlikely event that problems were to arise. As the supplier of choice for the propulsion system, ABB was also commissioned to supply a pilot version of its newest monitoring tool, the PCMS.

PCMS is based on DriveMonitor™, ABB's well-known diagnostic tool developed for medium- and low-voltage drives. PCMS takes the best aspects of DriveMonitor and expands their functionality to create diagnostic packages, such as pod and medium-voltage distribution network monitoring, that are specific to marine applications. The aspects that distinguish PCMS from other condition monitoring systems include:

- Scale
- Weight
- Data source versatility
- Sense of timing
- Intelligence
- Access and feedback

Scale

The Azipod is a sophisticated and complicated system. Apart from the pod itself with all its internal components, sensors and the multiphase synchronous motor, there is also: a lubrication system for the main, rolling-element shaft and slew bearings; the steering system; an air-cooling system for the motor; a frequency converter; supply and excitation transformers; a

Factbox 2 VSI-type propulsion in a cruise ship

Celebrity Solstice is the first cruise ship that utilizes voltage source inverter (VSI)-type propulsion frequency converters. VSI is known to provide improved efficiency – the power factor (cosphi), which is around 0.75 for cyclo-converters (this varies with loading), is practically constant at 0.95 over the entire operational speed range. At full load, it exceeds 0.95, resulting in an efficiency greater than 98.5 percent! The ACS 6000SD converter uses integrated gate-commutated thyristors (IGCTs) as the switching devices and the ABB patented Direct Torque Control (DTC) principle for synchronous motor drives.

The 6-phase motors have two 3-phase windings and each motor is normally driven by two VSI-type frequency converters. However, in the event that one of the converters is not available, the other is more than capable of driving the Azipod motor. A high level of redundancy and fault integrity has been built into the design to ensure that even with a single failure in any of the four frequency converters, 75 percent of the propulsion capacity remains.

The ever-watchful PCMS

Since so much effort has gone into creating a ship that is new in almost all aspects of design and operation, it seems only right to have some sort of supervisory system in place that is capable of listening to, recording and monitoring selected and critical components in the propulsion chain, and then correctly making a diagnosis in



Innovation on the move

medium-voltage distribution network with all its feeders and switchgears; electric generators; and finally the entire control network in which the main propulsion controllers ensure proper balancing between the speed set points sent from the ship's bridge and the total electrical power available in the system.

PCMS is unique in that it provides fundamental and valuable condition monitoring functions for off-shore vessels on a scale that had been previously very difficult to achieve.

The main data links between the PCMS system and Azipod components are shown in **1**. The system is either plugged into the operator's network or has independent, dedicated data links to particular devices. This allows the PCMS to access data – via the operator's network (green link in **1**) – supplied by the Azipod's interface unit controller and the protection relays in the medium-voltage distribution network as well as the signals handled by the main propulsion control. A fiber-optic Distributed Drive Communication System (DDCS) link between the PCMS and the frequency

converter (in blue) is used to transmit parameter changes, as well as fault, event and alarm information generated inside the converter.

Connectivity to non-ABB condition monitoring devices is achieved using a specially developed software and hardware layer (black link).

Weight

Data collection, processing and storage are performed using a simple but flexible and "hidden" distributed setup. Each Azipod pod contains an embedded robust and compact DriveMonitor PC, which is installed inside the propulsion control unit (PCU) cabinet. All incoming data from this pod is processed in a single DriveMonitor box. A third PC, known as the PCMS server, is used to store and display all pod measurements, and is located in the main electrical control room. From the system's performance perspective, this setup can be easily configured to handle and balance different loads in case the system needs to be restructured.

Data source versatility

Azipod incorporates a large number of devices. Some communicate with each other using industry-standard communication protocols while others are simply hardwired together, with mea-

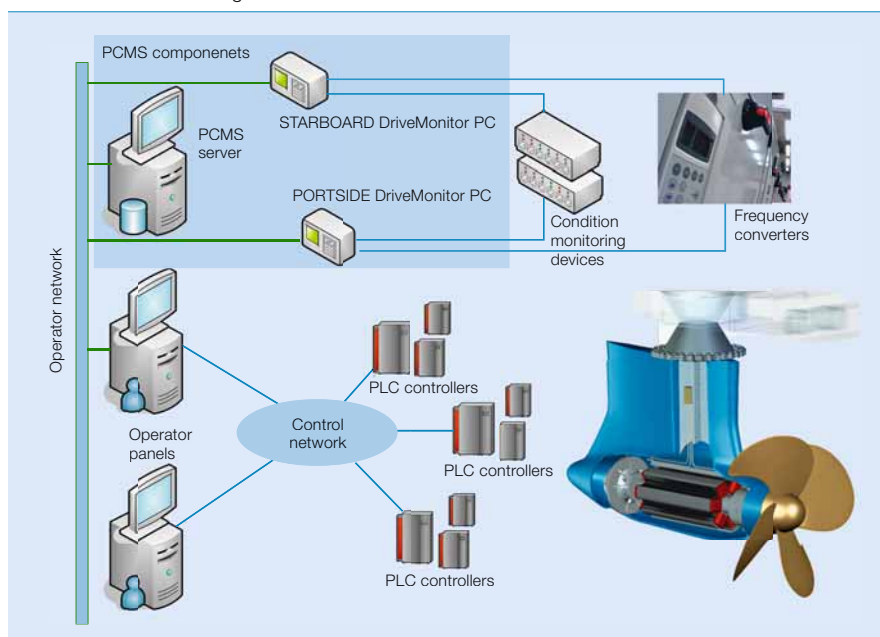
surement and set-point values indicated by current and voltage levels. Even though the Azipod is an important part of a ship's construction, data from it alone is not enough to properly monitor a ship's overall performance. For this reason, PCMS also collects information from several other onboard non-ABB systems. To overcome the differences that exist in the various data formats, PCMS uses OPC³⁾ connectivity.

In principle PCMS is a client application for OPC data access and alarm and event (AE) servers, meaning it can read measurements as numerical data and import alarm and event type signals. There are cases where non-ABB devices are used that are not OPC compliant and tailor-made OPC servers, developed by ABB, are needed to read their data. One such example is a vibration condition monitoring device located inside the pod, which collects and processes vibration data from the main shaft bearing frame. Information about the status of the bearing is given to the Azipod control system as a relay output. In parallel, raw vibration measurements, together with spectra and some calculated indicators are sent from the pod to the PCMS system via a wireless link running on one of the DriveMonitor boxes.

In principle PCMS is a client application for OPC data access and alarm and event servers.

Another example concerns bridge nautical systems. In order to collect information about the ship's speed, course, trim, heel and the sea conditions, an OPC server has been implemented to interface with the National Marine Electronics Association (NMEA) protocol.⁴⁾ This server resides

1 PCMS connection diagram

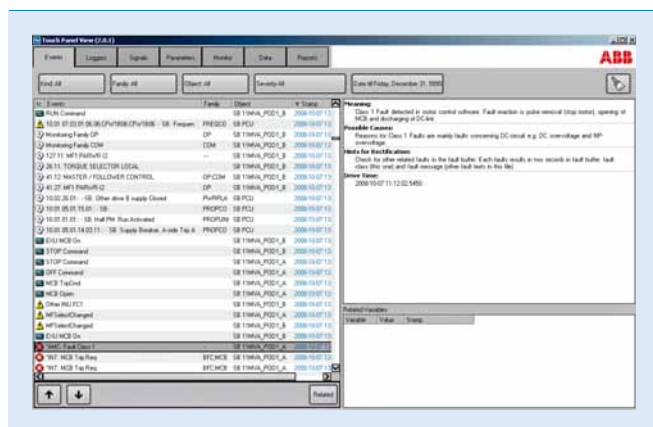


Footnotes

³⁾ OPC stands for Object Linking and Embedding (OLE) for Process Control and represents an industry standard that specifies the communication of real-time data between devices from different manufacturers.

⁴⁾ NMEA is a combined electrical and data specification for communication between marine electronic devices.

- 2 An alarm and event list with an example of a fault from a frequency converter generated during the commissioning tests



in one of the DriveMonitor boxes and is connected to the nautical systems by a direct serial link. It converts NMEA sentences into OPC tags with recent values.

Currently, efforts are underway to develop a customized OPC server for protection relays that is capable of transferring transient recorders. These recorders are like snapshots of electrical transients (ie, phase voltages and currents) and are an indispensable source of information for a PCMS system in its attempt to find the real cause of a problem.

ABB's PCMS is flexible in that it implements various data collection scenarios to suit various aspects of a ship's design.

Sense of the time

The rate at which a component deteriorates or a fault propagates varies from device to device. Different scanning frequencies are sometimes required to measure various physical properties. However, it doesn't always follow that the higher the sampling frequency, the better the measurements that lead to fault detection. ABB's PCMS is flexible in that it implements various data collection scenarios to suit various aspects of a ship's design. Consider, for example, the bearings on the ship: Proper condition monitoring means supplying the operator with continuous informa-

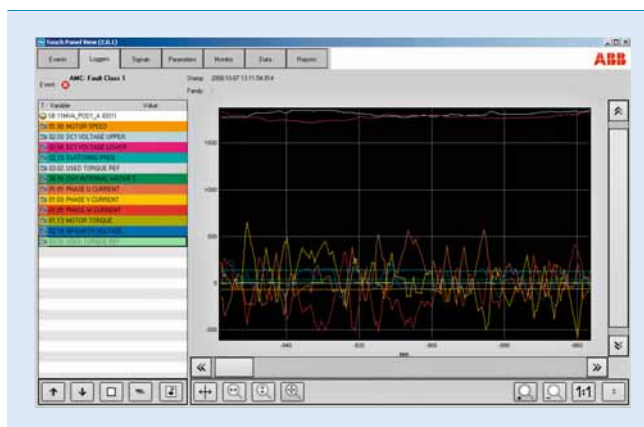
tion about both the main-shaft bearing vibrations and the number of metal particles in the bearing lubrication oil. Acquiring this information requires two separate measurement techniques, something the PCMS is capable of doing. It contains a Bearing Asset Monitor (BeAM) package that measures the vibrations using a sampling frequency of 41 kHz, while the number of particles in the oil is updated every 30 minutes.

Intelligence

PCMS is capable of collecting and processing raw measurements according to user-defined rules (ie, equations or formulas). For example, once an hour the system checks to see whether the azimuth angle and rotational speed of the shaft are within a certain range. If this is the case, the PCMS then checks when the last vibration measurement was taken and stored. If this occurred more than 24 hours previously, BeAM is triggered to sample vibration data over a period of 6 s at a high frequency. This sample is then processed by PCMS diagnostic algorithms to find the existence of shock-pulse transients, which are early indicators of a bearing fault. The entire procedure only happens once a day on condition that the angle and speed are within the specified range.

Another diagnostic package calculates operating profiles. For the sake of additional reliability calculations, the PCMS continuously calculates the total time the Azipod operates in different load zones, ie, for different azimuth

- 3 Loggers associated with a drive fault



angles, propulsion power and shaft rotational speeds.

The PCMS installation onboard Solstice also contains a monitoring solution for the medium-voltage distribution network. The main component in each switchgear pole is an intelligent protection relay connected via SPA to a PROFIBUS gateway to an AC800M PLC controller. This solution allows PCMS to define and monitor key efficiency indicators, such as the total power distribution between working generators, the load of individual generators and the balance between generated and consumed energy.

PCMS is capable of collecting and processing raw measurements according to user-defined rules, ie, equations or formulas.

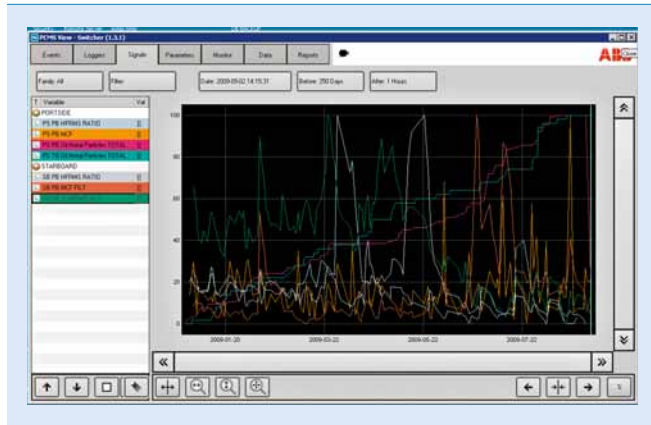
Access and feedback

The main PCMS user-interface panel is located in the ship's engine control room. The amount of information given and the way it is displayed is customized according to the user type, which in most cases is either operator or service. Service engineers can remotely log into the system, something that is crucial if a quick and accurate diagnosis is needed.

The interface panel contains alarm and event information from the main Azipod components. Events are capa-

Innovation on the move

- 4 Selected signals – for example metal scan readings, high-frequency root mean square values, modified crest factor trend – related to the main shaft bearings (in percent)



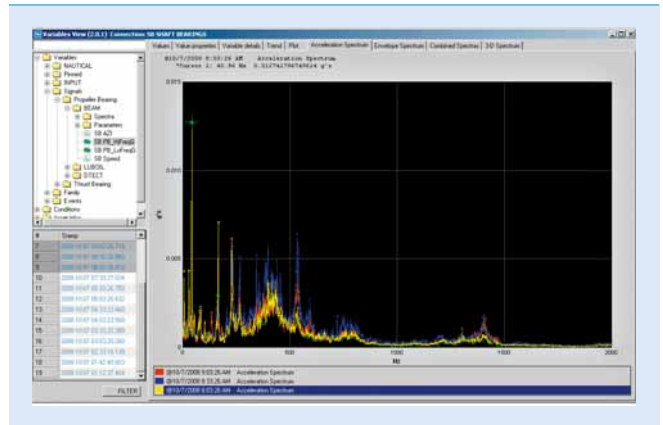
ble of giving additional information if required, such as “possible cause” or “hints for rectification,” and they are linked with particular loggers and signals that belong to the same monitoring group and that were collected at the time the event occurred [2] and [3]. Aggregating information from different sources and displaying it on one view brings added value to the fault tracking process. Various signal trends, both measured and calculated, from the main shaft propeller and thrust bearing are shown in 4. Specially developed views make it easy to analyze complex data types. The screenshots shown in 5 and 6 illustrate how a vibration spectrum can be managed using harmonic and side-band cursors or waterfall plots.

ABB’s PCMS is able to generate automatic reports that contain a selected subset of recorded data over a specific period. Reports are designed to include general information about Azipod system performance, such as critical faults and the current condition of main components.

Looking to the future

PCMS is the first of its kind in that it is a scalable and flexible solution that provides fundamental and valuable condition monitoring functions for offshore vessels on a scale that had been previously very difficult to achieve. However, this is really only the starting point when one considers that more and more components and systems in the future will be covered

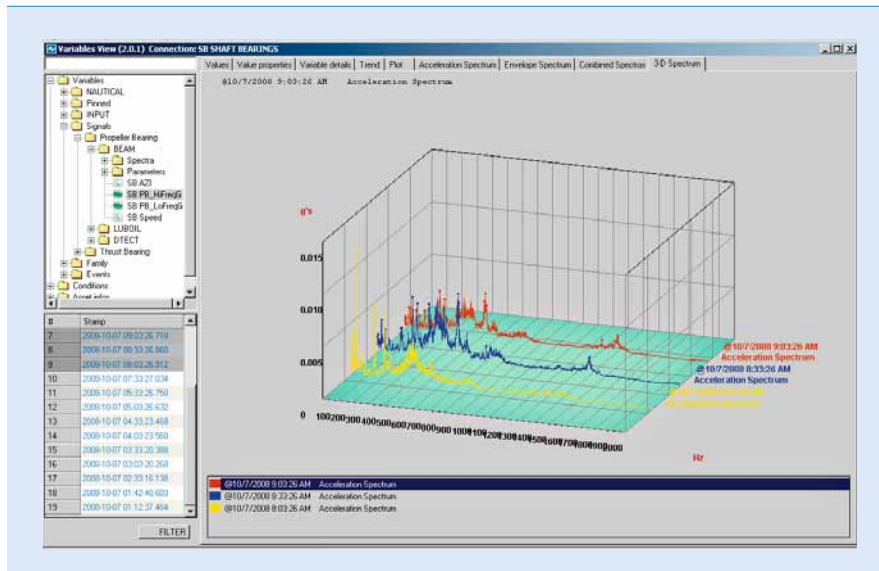
- 5 An acceleration spectrum for vibration measurements



by intelligent and automated diagnostics, thus raising productivity to a new level.

The development of PCMS focuses on improving technical performance and building new service scenarios. The ultimate goal is to have a system that has complete surveillance around the ship’s critical systems and full control over the performance and life cycle of the complete fleet.

- 6 3-D waterfall plots with vibration spectrums



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Propelling ahead

Developing the second-generation Azipod® propulsion system, Azipod® XO

Lauri Tiainen, Antti Lehtela

Over the years, ABB's Azipod® propulsion system, renowned for its high maneuverability, quick response, fast cruising speeds and smooth, quiet operations, has proven itself in the shipping industry. The unit has led to increased efficiency, lower emissions, reduced building time and improved ship design, and is the market leader in podded propulsion technology. Development of the Azipod system began some 20 years ago, and the product has evolved into a major propulsion system for luxury cruise liners and icebreakers.

But surely the Azipod could do even better?

ABB turned to Azipod users for feedback to help evaluate the system. The result was a comprehensive development program initiated in 2006 to create a new Azipod generation. The strategy was not only to focus on technical issues, but also to address safety, maintainability, reliability, production, human interface, life-cycle costs, environmental factors and other design aspects.

This article describes the development project and highlights the new innovations applied to the final product. The result, Azipod® XO, was put on the market in September 2009.



Innovation on the move

Azipod is a submerged pod containing an electric propulsion unit consisting of a variable-speed electric motor, which drives the fixed-pitch propeller. The pod can rotate freely along its vertical axis to give thrust in any direction. Thus the ship does not need rudders, stern transversal thrusters or long shaft lines inside its hull.

Much development has been done and improvements have been made to the Azipod since its introduction in 1990. Until recently, however, the Azipod was still very much a first-generation product. After the initial revolutionary development the product has undergone only incremental design changes. These have largely been customer oriented, providing optimized solutions for each client. Since the delivery of each system is project based, maintaining uniform operation and design patterns has been challenging.

Because of its remarkable and proven advantages, podded propulsion was projected to expand to new ship types. This expectation, in combination with customer feedback on the existing Azipod system, has provided the impetus to develop a new, second-generation Azipod propulsion system.

Operators, authorities and shipbuilding yards each have their own requirements, thus a comprehensive approach to designing a new system was taken.

Setting priorities

The initial challenge was to determine what is important for a new system, what exactly should be developed, and what the overall target should be. After careful pre-studies, customer questionnaires, and workshops with key industry players, the following goals were set:

- Improve the lifetime earning potential of the ship through improved total operational efficiency
- Enable flexible, controlled and cost-efficient customization through modularization

- Make assembly easier and shorten onboard assembly time
- Reduce engineering lead time and project-specific design time
- Minimize manufacturing lead time and costs
- Enhance the safety of the system
- Reduce fuel consumption and emissions and as a result minimize the ecological impact

A propulsion unit that provides both propulsion and steering functions to a ship is an essential part of a vessel. Of course it moves the vessel from one port to another, but it is also, from a safety point of view, one of the key systems onboard ships. The unit is a combination of both mechanical and electrical engineering, includes modern communication technology, and utilizes hydrodynamic behavior for propulsion efficiency and maneuverability.

Operators, authorities and shipbuilding yards each have their own requirements – the latter, for example, desiring easy installation and efficient commissioning. To help meet this wide range of needs, a comprehensive approach to designing a new system was taken. The project was divided into seven subprojects:

- Modular propulsor family
- Risk and reliability management
- Modular electric steering gear family
- Modular assembly block family
- Condition management system
- Intelligent maneuvering interface
- Development of dimensioning principles

The “modular propulsor family” subproject was the biggest and most challenging, as it focused on the most physically significant part of the Azipod product – the underwater unit – which includes the electric motor, bearings, seals and propeller. The development process of this subproject and the resulting innovative solutions are highlighted here.

A multitude of expertise

Although the core R&D team for the new propulsor unit consisted of only 15 people, the total number of participants, including the interviewed customers, was about 100. Expertise from many organizations, customers, ship-

yards, ship operators, equipment manufacturers, research laboratories, universities, consultants, designers, etc. from more than 15 different nationalities were involved in seeing this project through.

About 10 customers from a wide range of companies all over the world were interviewed to obtain their opinions on the most important features and needs. These discussions generated a range of new ideas for developing technical solutions, which the customers influenced throughout the development process. In the end, the final solutions fulfilled the interests of all – customers, ABB and sub-suppliers.

A propulsion unit is a combination of both mechanical and electrical engineering, includes modern communication technology, and utilizes hydrodynamic behavior for propulsion efficiency and maneuverability.

Royal Caribbean Cruises, the most experienced user of podded propulsion, was one customer that participated actively in the process. Its long operational history, good knowledge of existing Azipod designs, and its positive attitude toward the discussion of new ideas led to the development of real innovations. Ideas that initially looked promising to ABB were not always the best choice from a customer perspective. Getting this kind of feedback helped ABB to concentrate on features that were essential to customers.

In the design phase, features that would improve human safety during installation, operation and maintenance of the product were given special attention. Design elements that would improve the space restriction for those required to move around inside the Azipod hull during its maintenance were particularly important. In addition, a team of students from the Helsinki University of Technology was invited to develop special work gear

for those needing to work in these confined spaces.

The development team also participated in ABB's Marine Academy confined space course, together with the operating crew from several ships, to learn a practical approach to inner-Azipod operations. Training in an Azipod simulator was found to be very useful for people making decisions about the future Azipod.

Visualization is the key

At the beginning of a development project it is important to generate ideas to ensure that set targets are met. With an open-minded approach and a highly motivated team, this phase was very successful. In fact, at the concept-design phase, over 100 ideas were generated. From these ideas, 23 were developed into more detailed concepts, 10 of which resulted in an engineered solution. Five different pod frame concepts also were developed ¹.

Once concepts were ranked in order of priority it was time to start the technical investigations – ie, to check out the technical feasibility of those ideas. The challenge at this stage was to create visualizations of the concepts so that potential solutions could be easily discussed with other stakeholders. An industrial designer was a huge help at this stage, being able to illustrate sometimes unknown or “fuzzy” ideas. Also, miniature models and mock-ups were used to clarify the

details. How, for example, could the team ensure that changing of shaft seals would be possible inside the Azipod? The answer: Build a wooden mock-up, put design and service engineers inside the mock-up with tools, and ask for their feedback! The input and original idea for this exercise actually came from interviews during the development phase with one of ABB's biggest customers.

In the design phase, features that would improve human safety during installation, operation and maintenance were given special attention.

Modular design

The experience gained from the first-generation Azipod units was that future Azipod generations should be of modular construction. This philosophy has a few benefits: Through standardization the product quality is improved, the manufacturing process is improved, and in the long run the total cost will be lower. However, it is

essential that each modular solution be designed carefully so that most customers' needs will be satisfied with one or more options from the modular product family.

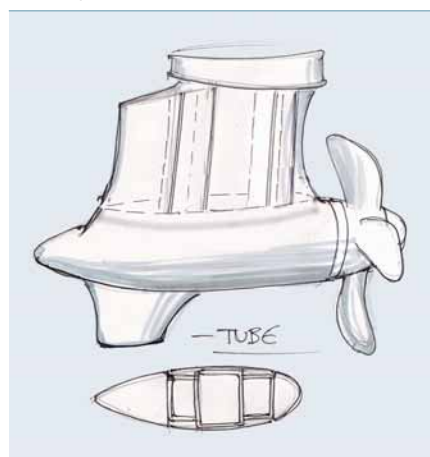
To fulfill the requirements of modularity, the project team had to consider many different approaches and solutions. Customer comments were again of great value. In the end, the Azipod product family was made to include roughly 300 modules and around 50 optional modules. With a product “pallet” like this, fast and reliable response to different customer requirements was ensured.

Hydrodynamic development

Podded propulsion has already improved hydrodynamic efficiency by about 10 to 15 percent, as compared with conventional electric shaft line systems. However, the project team was encouraged to further investigate the possibilities for reduced energy consumption and thus reduced CO₂ emissions of the vessel.

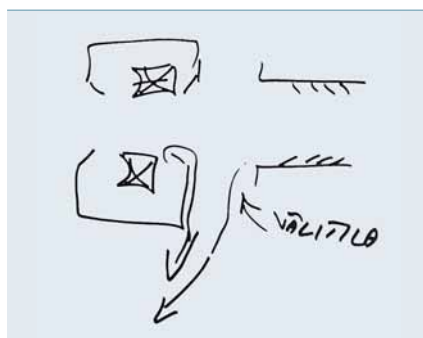
Being a complex product with many different objectives and considerations – eg, maintainability, installations to the ship and cost – hydrodynamic de-

¹ Artist's view of one of the initial pod housing designs, which was chosen for the final design of the Azipod XO

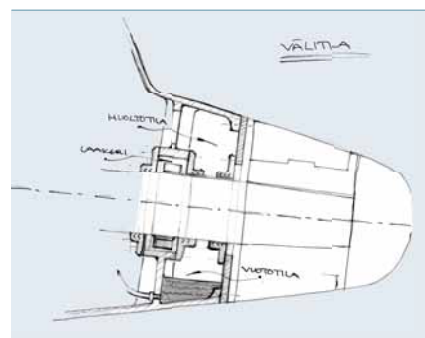


2 Interspace evolution

a The first sketch



b Draft of interspace



c Interspace mock-up



d The final model



Innovation on the move

3 Model of the new hybrid bearing developed for the Azipod XO



4 An inside view of the Azipod XO



sign changes were limited and compromises made. Roughly 15 different hydrodynamic shapes were developed and analyzed with CFD (computational fluid dynamics). Also many test sessions were held at the model basin¹ to verify the usability of the original ideas. Finally one shape was selected for the new Azipod. To the outsider, the new hull looks quite similar to that of the previous generation. However, the propeller hub and Azipod hull diameters were reduced and the Azipod strut shape modified. This new shape allows for about a 2 percent improvement in hydrodynamic efficiency in the tested case.

The interspace concept makes seal maintenance inside the Azipod possible and reduces the risks of operation.

Another important finding was that by changing the vertical turning axis of the pod unit the steering torque could be reduced by about 20 percent – even more depending on the ship's speed. This means smaller steering-system dimensioning, greater energy savings and less wear on the steering mechanics.

Creating interspace

One example of an open-minded and innovative solution is the new sealing system for the propeller shaft. It is easy to imagine that if seawater leaks inside the pod and reaches the high-

power electric motor, there will be so much damage to the equipment that a costly and time-consuming dry-docking would be needed to repair the motor. Equally important is that the lubricants from the bearing do not leak to the sea, for both environmental as well as financial reasons. If even a small drop of oil is seen around the ship at some cruise liner destinations, the liner companies may be made to pay extremely high fees for the resulting environmental cleanup.

Typically, shaft-seal development work involves seal materials, housing developments and the like. In this project, however, the development team took almost the opposite approach to the problem by completely turning the traditional seal package around – literally. This was established as the interspace concept (patent pending)². The concept makes seal maintenance inside the Azipod possible and reduces the risks of operation.

By collaborating with customers and really defining and understanding their needs, a crazy idea was transformed into a revolutionary concept.

Hybrid bearing

As many in the marine business know, podded propulsion bearing solutions are quite famous and not always in a positive way. So, development was mainly focused on extending a ship's dry-docking interval during which time the thrust bearing could be replaced. Eventually, it became appar-

ent that if this replacement could happen without dry docking, there would be no need to focus on increasing a dry-docking interval. This concept was fully supported by the customer, and blossomed into the invention of the hybrid bearing (patent pending)³.

The result of a systematic search for solutions, a hybrid bearing is in principle a very simple bearing arrangement combining two well-known bearing technologies – a slide bearing for axial forces (thrust bearing) and a roller bearing for radial forces. Until now, this combination of bearings had not been introduced to the marine market. For the new Azipod generation, the hybrid bearing would replace the traditional thrust bearing.

Hydrodynamic developments, such as pod and propeller-hub diameter reduction and strut-shape optimization, increase efficiency by about 2 percent.

Introducing the new Azipod XO

This intensive development project has transformed the Azipod into a truly user-based propulsion system, designed with the customer, for the customer. And the benefits of the new Azipod XO are many⁴.

Hydrodynamic developments, such as pod and propeller-hub diameter re-

duction and strut-shape optimization, increase efficiency by about 2 percent. For a typical cruise vessel application, this alone results in nearly \$700,000 in annual fuel savings and a corresponding reduction of 5,000 metric tons of CO₂. That is a lot!

This intensive development project has transformed the Azipod into a truly user-based propulsion system, designed with the customer, for the customer.

To illustrate the importance of this improvement, CO₂ emissions produced during the whole Azipod production

process are “paid back” within about eight months of operation. Add to this the 10 percent increase in efficiency already achieved with the first-generation Azipod, and the savings are even more impressive!

The Azipod has been designed for optimized maintainability, allowing maintenance of seals and thrust bearings to be performed inside the pod. This is a benefit in itself, but it also allows for extended intervals between dockings, opening up possibilities for future needs in the shipping business.

The use of an electric steering system, which replaces the hydraulic solution, enables easier installation, improved efficiency, reduced need for maintenance and less noise.

Through the intelligent bridge control interface, deck officers get real-time information about the system, allowing them to operate their vessels in a gentle and optimal way, minimizing the stresses to the system and reducing fuel consumption.

Advanced condition monitoring records the condition of the critical sub-systems, such as the propulsion and steering systems, bearings and seals, as well as lubrication systems, and allows the optimization of the maintenance operations for the systems.

For shipyards, the benefits include flexibility in integrating the Azipod into the ship hull, easier installation due to modular construction, and avoidance of high-pressure hydraulics in the steering system.

With the new Azipod XO system, ship owners will save even more money, the environmental impact will be even lower, and business operations can be more easily planned as a result of a reliable and maintenance-friendly propulsion system. The first Azipod XO unit is already on the market **Factbox**.



Factbox Azipod® XO2100 specifications

Type designation	Azipod XO2100–S3000E4
Rated output power	13,000–18,000 kW
Nominal propeller speed at maximum output power	122–170 rpm
Main motor supply voltage	Approx. 3,000 V
Insulation/temperature rise class for stator and rotor	F/F
Propeller design	4 or 5 blades
Propulsion module (excluding propeller)	135,000–155,000 kg
Propeller	22,000–30,000 kg
Steering module	60,000–70,000 kg

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Footnote

¹⁾ A physical basin or tank used to perform hydrodynamic tests

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Siemens press picture

High-speed transformation

Transformers for the Velaro high-speed train

Cécile Felon, Andreas Moglestue, Cyril Montacq, Christian Vetterli, Harry Züger

Concerns over carbon emissions from transportation, combined with the increasing congestion of road and air space are causing many countries to rethink their transportation policies. New investments in transportation, such as commuter systems to serve major cities, or high-speed lines to connect cities over distances of several hundred kilometers, are contributing significantly to fuel savings and the reduction of CO₂ emissions.

High-speed rail is particularly effective at taking pressure off short-haul flights, reducing air congestion and bringing cities closer together. Japan and several European coun-

tries have been investing in high-speed railways for several decades and now have extensive high-speed networks. The rapid development of emerging economies, together with concerns ranging from rising fuel prices to global warming, have led more and more countries, on different continents, to look toward high-speed trains as an alternative transport solution. Manufacturers are meeting this growing interest by rolling out a new generation of ultra-fast trains – offering higher performance and more sophisticated technology than their predecessors.

One of these trains is Siemens' Velaro.

ABB Sécheron traces its collaboration with Siemens Mobility to 2003, when ABB won a significant order to supply 140 +100 traction transformers for the double-decker trains of the Siemens' Desiro family for the suburban rail system of Zürich, Switzerland (S-Bahn Zürich) ¹. A special challenge here was that the transformer had to be extremely light and compact as the design objective of the train was to maximize the space available for passengers.

In 2004, ABB was awarded an order to supply 172 EMU (electrical multiple units) transformers for suburban services in the Mumbai area (India). In this project, ABB's ability to provide local content proved an advantage in obtaining the contract. A second major Mumbai order followed in 2006

Factbox 1

Building on this success, ABB secured a further traction transformer contract with Siemens in 2008, this time for trains destined for the Scottish railway franchise, Scotrail.

In June 2009, ABB won a prestigious order with Siemens Mobility: to supply transformers for Siemens' flagship Velaro high-speed trains.

The ICE-3 and Velaro differ from the first generation of European high-speed trains in that they are not pulled by dedicated locomotives or power units, but use a distributed-traction concept.

The Velaro high-speed train

Velaro traces its origins to the ICE-3 train, which was supplied to German Railways (DB) from 2000, and operates at speeds of up to 320km/h in commercial service ².

The Velaro is a development of the ICE-3. In contrast to its predecessor, for which Alstom LHB, Bombardier/DWA, and Siemens were jointly responsible, the Velaro is entirely the

responsibility of Siemens Mobility. Velaro trains have been sold to Spain (2001: 26 eight-car trains for Madrid – Barcelona), China (2005: 60 eight-car trains for Beijing – Tianjin and 2009: 20 eight-car trains and 120 16-car trains for Beijing – Shanghai) and Russia (2006 : eight 10-car trains for Moscow – St. Petersburg). With a power of 8,800kW, (10 percent more than the ICE-3) the Spanish train can reach a top speed of 350km/h.

Factbox 1 Mumbai suburban railway

The Mumbai suburban railway has the world's highest passenger density: It is used by 6.3 million commuters every day. The system extends over 319 route km (790 track km) and is divided between two of India's zonal railways: Western Railway (WR) and Central Railway (CR). It uses a total of 191 train rakes (train sets) to operate, 2226 daily train services.

To alleviate overcrowding and provide additional capacity, a massive investment program has been launched. This includes:

- Boosting capacity by adding 181 km of additional tracks
- Extending station platforms to permit longer trains
- Improving signaling systems to permit trains to run at shorter intervals
- Procuring new trains

The works will permit the total number of trains operated every day to be increased by 25 percent. Overcrowding will be alleviated by reducing the commuter load of a 9-car train from 5,000 to 3,600 passengers.

The total cost of these measures is estimated at \$943 million³ of which 57 percent is provided by a World Bank loan.

The first phase included the procurement of 101 new trains of 9 cars each, with 97 more following in the second phase. As the works also include a phased conversion of the railway's electrification system from 1,500V DC to 25kV 50Hz, the new trains are dual voltage, permitting them to work on both systems during the transition period.

The trains are being built by Siemens in cooperation with the Indian company, Inte-

The ICE-3 and Velaro differ from the first generation of European high-speed trains in that they are not pulled by dedicated locomotives or power units, but use a distributed-traction concept. This means that all traction equipment such as traction motors, transformers, cabling and auxiliary equipment is distributed along the sub-floor space of the vehicles. As a result, the full length of the train is available for passenger accommodation. This approach permitted the capacity of the



Source: Integral Coach Factory (ICF)

gral Coach Factory (ICF). ABB is sub-contracted to supply the traction transformers.

Further features of the new trains include:

- Energy savings of 30 percent due to regenerate braking
- Use of three-phase traction motors permits 20 percent higher power
- Top speeds of 100km/h rather than 80 as on previous train types
- Higher acceleration 0.54m/s² as compared to 0.38 for previous trains.
- Deceleration similarly improved to 0.76m/s² from 0.6.
- Journey time on a typical Churchgate – Borivali or CSTM – Thane trip reduced by four to five minutes.
- Passenger comfort improved through a broad range of measures including better riding quality, improved ventilation, passenger information displays and better lighting.

For more information, see www.mrvn.indianrail.gov.in.

³ 45,260 million Indian Rupees

Innovation on the move

1 A Desiro Double Deck or train of Swiss Federal Railways (SBB) used on the Zürich suburban system (S-Bahn Zürich). These trains have ABB transformers. [Siemens Press Picture]



2 An ICE-3 high-speed train of German Railways (DB). These trains have a top speed of 320km/h.



train to be increased by some 20 percent while at the same time augmenting levels of passenger comfort.

The next Velaro order was placed by German Railways (DB) in December 2008 ³. These 15 trains differ from the previous Velaro orders in that the train will be used on international services and must be equipped to work in four countries (France, Germany, Belgium and Switzerland). They must operate under four different power supplies and be compatible with the different safety and signaling systems of the respective countries.

In June 2009, Siemens Mobility entrusted the supply of the traction transformers to ABB. Ralf Mayer of Siemens Mobility said “ABB met the challenging requirements, eg, size and weight, of these special transformers in a very convincing manner – so we chose ABB as a reliable partner for the Velaro D project.”

The Velaro challenge

The Velaro's transformer posed several engineering challenges.

If a traction unit fails, the train must be able to continue its journey with 75 percent of its maximum traction and brake power in complete safety. This includes the train's ability to start and stop on steep gradients (the train is expected to cope with gradients of up to 4 percent, double that of conventional trains).

All this is achieved at great levels of energy efficiency. With an equivalent gasoline consumption of 0.33 liters per person per 100 km, Siemens claims Velaro to be the “world's most ecological train.”

Two traction transformers will be fitted to every eight-car train. In order to save weight, the secondary windings of these transformers also serve as line inductances for the power converters when the train is operating under a DC power supply. Thanks to this economic weight-saving principle, the mass of the entire transformer assembly (comprising the 5,220 kVA traction transformer and its cooling system) could be reduced to 7,700 kg.

The traction transformer and its cooling system jointly form a plug-and-play assembly.

This principle of combined use of windings was first installed on the Italian locomotive type, E412, in 1996. It has since been adopted by other vehicle types including the ETR 500¹⁾, AGV²⁾ (NTV³⁾ high-speed trains) and the Traxx MS⁴⁾ locomotive.

The transformer's enclosure is manufactured out of weight-saving aluminum. Further weight is saved by integrating the expansion reservoirs (for the coolant fluid) with this unit. The cooling system uses 60 Hz motors

rather than the more common 50 Hz ones permitting their mass to be reduced without sacrificing cooling performance.

Capacitor-based filters have been added to reduce resulting harmonics. Railway applications are extremely sensitive to harmonics as these can cause interference with signaling systems. Hence requirements are very stringent, demanding great diligence in addressing such issues.

The traction transformer and its cooling system jointly form a plug-and-play assembly, useful for installation and for maintenance. This was an unusual concept for Siemens, as the company normally sources the transformer cooling system separately from the transformer. The unit does not require de-gassing or oil refilling, and so can operate for prolonged periods with minimal intervention.

Further challenges were posed by the very demanding timelines to which ABB had to work, as Siemens required the delivery of the first transformer in December 2009.

Footnotes

¹⁾ ETR 500 is a high-speed train operated by Italian Railways (Trenitalia) and manufactured by a consortium of suppliers.

²⁾ AGV (automotrice à grande vitesse) is a high-speed developed by Alstom as a successor to the TGV. Similarly to the Velaro, it uses distributed traction.

³⁾ See [Factbox 2](#).

⁴⁾ Traxx is a family of universal locomotives manufactured by Bombardier Transportation.

3 Impression of the Velaro-D train that will be supplied to DB
[Siemens press picture]



A future at high speed

ABB Sécheron has managed to build an excellent working partnership with Siemens Mobility. This was based both on ABB's ability to draw on its expertise in traction-transformer design and apply this to the demands of high performance under restricted space and weight limitations **Factbox 2**, but also its high responsiveness and willingness to collaborate. ABB's support staff made themselves available at all times, including weekends, to attend to queries at meetings, by phone, e-mail or on-site to share their expertise.

Siemens' ability to rely on ABB is of the greatest importance. Being responsible for the project, Siemens must bear the liability and penalties

for late delivery or malfunctions of the finished train – yet with acceptance procedures being required in four countries, the timeline is extremely demanding. Siemens must thus be able to count on reliable partners who will do everything in their power to avoid inducing delays of their own. ABB is in continuous contact with Siemens to discuss progress and review technical issues. At the same time, ABB is working together with the end customer (DB) on various quality-related issues defined by the customer such as enclosure welds.

With projects for high-speed trains being considered in many countries and continents, fuelled by environmental concerns, airspace congestion or driven by the rapid economic

growth of many developing countries, the global market for high-speed rail is certain to see some exciting development in years to come. ABB's motto for rail transport of the future is "Let the brain fly but your body takes the train."

Railway applications are extremely sensitive to harmonics as these can cause interference with signaling systems.

The Velaro project is not only a good starting point for further high-speed orders, but also demonstrates ABB's competence in the design and supply of traction transformers for all types of applications.

4 An ABB traction transformer for the Velaro D train



Factbox 2 ABB and high speed



ABB draws on considerable experience in designing and manufacturing transformers for high-speed trains. The highlights of this include:

- The TGV/AGV train that set the world speed record of 574 km/h on April 3rd 2007 (see inset photograph) used an ABB transformer. The train had conventional power cars at the extremities, and

additionally used two AGV power bogies under the passenger cars.

- NTV (Nuovo Trasporto Viaggiatori, Italy's first private operator) will use AGV trains equipped with ABB transformers.
- Siemens Velaro for DB uses ABB transformers.

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A plug for simplicity

X-Plug™ wiring technology for the ZX family of switchgear

Ralf Henke, Sven Wehrmann, Gerhard Salge, Thorsten Fugel

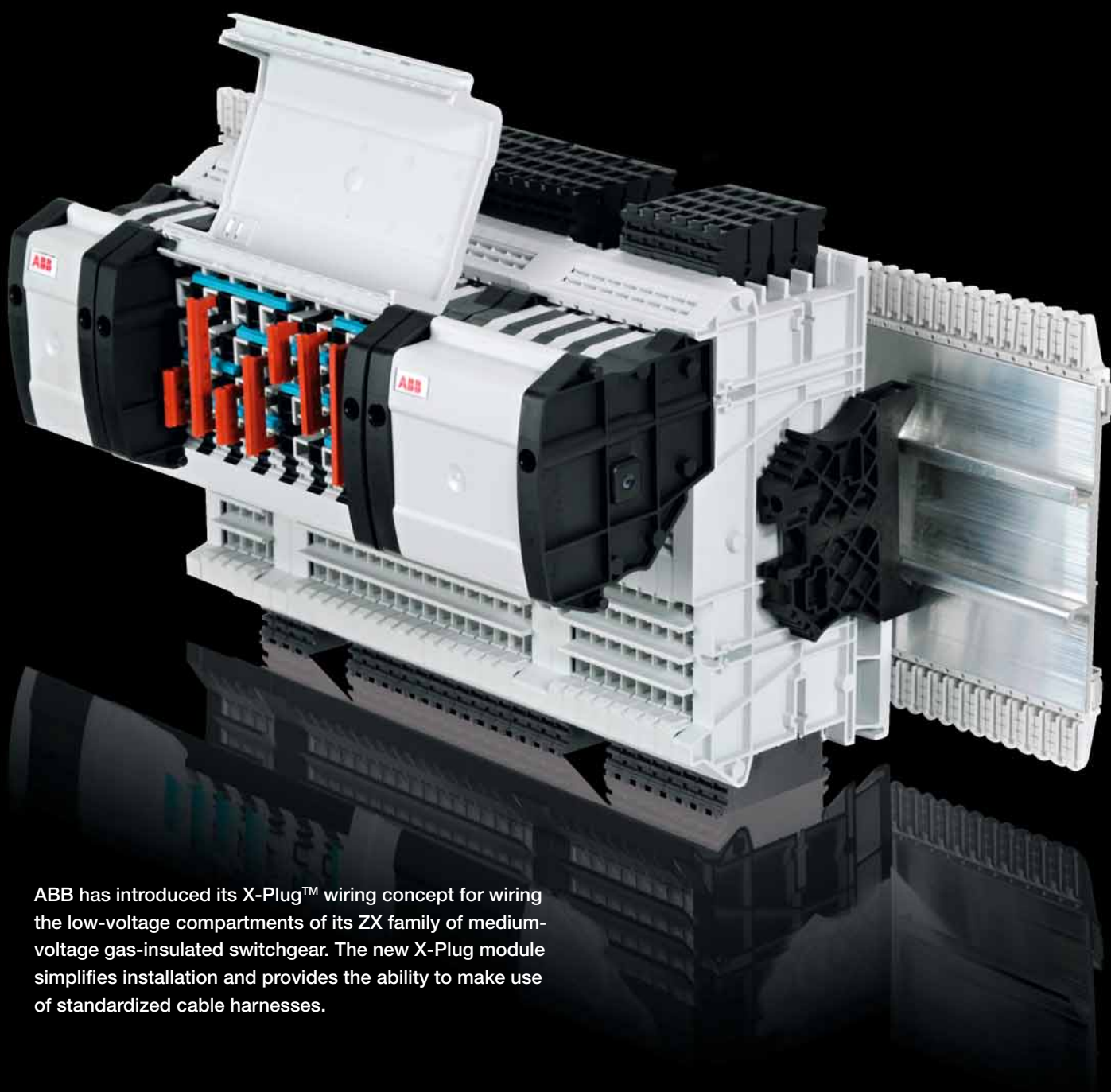


ABB has introduced its X-Plug™ wiring concept for wiring the low-voltage compartments of its ZX family of medium-voltage gas-insulated switchgear. The new X-Plug module simplifies installation and provides the ability to make use of standardized cable harnesses.

A conventional secondary low-voltage compartment used for the control of a switchgear installation contains a wide range of discrete components. These include push buttons, indicator lights, indicator instruments for current and voltage, measurement transformers, intelligent electrical devices (IEDs), auxiliary relays and auxiliary mechanical contacts. To make these assorted items fulfill their intended functions and work together as one protection and control cabinet, they have to be wired accordingly. However, the topology of this wiring varies from application to application. The broad range of possible functions, components and customer demands and specifications mean it has until now not been possible to standardize to any appreciable degree. Every cabinet had to be wired individually in a time-consuming and costly process.

Rather than individually wiring each device to all the others, the X-Plug™ makes it possible to connect all devices to one module.

Furthermore, the broad range of possible applications leaves little potential for standardized cable harnesses (preconfigured bundles of cables with plugs on both ends). The wiring of such cabinets can easily acquire a

spaghetti-like aspect, presenting a potential source of errors and impeding maintenance and modifications.

Now what if all this could be replaced by a simpler concept?

The X-Plug™ concept

ABB has introduced a new wiring approach to its ZX family of medium-voltage switchgear **1**. Rather than individually wiring each device to all the others, the X-Plug™ makes it possible to connect all devices to one module using standardized cable harnesses. The individual marshalling of all signals is managed inside the plug, and the connection topology has been

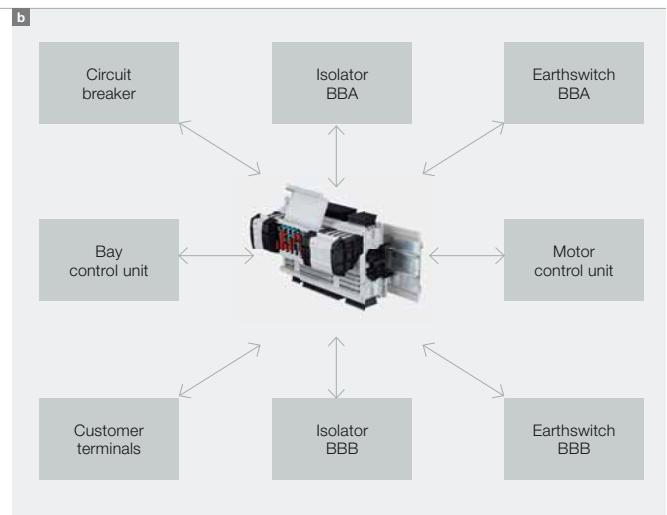
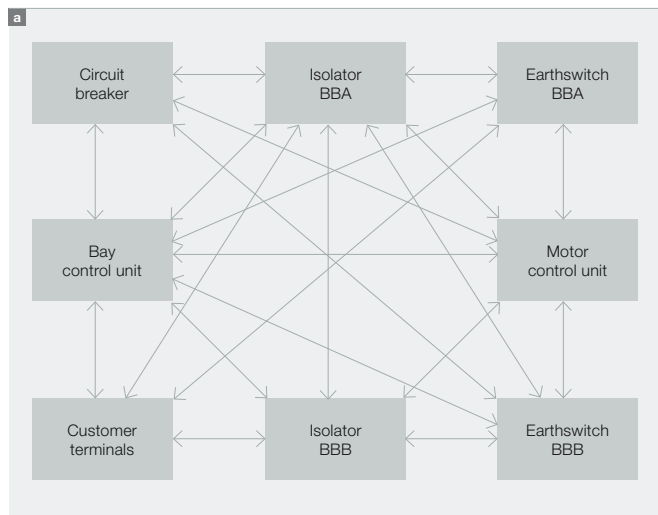
moved from the panel to the inside of these plugs **2**.

But is this approach not just shifting the wiring problem from the cabinet to the plug? No, because rather than all devices in the cabinet potentially having to be connected to all other devices calling for a large range of connections, wire lengths and wire routings, the equipment now only needs to be connected to the X-Plug using standardized connectors. As all wires coming from the equipment now end at the plug's terminals, this reduces the number of wire connections (X-Plug can save up to 50 wires for a ZX2 double busbar panel) and

1 ZX-family gas-insulated switchgear

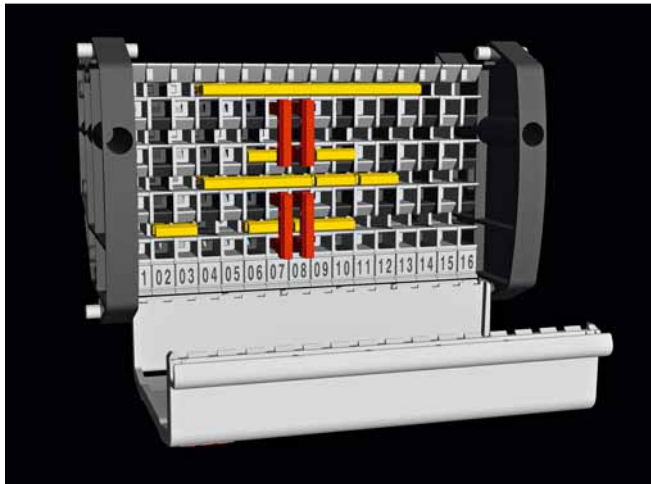


2 Connection topology: traditional **a** and X-Plug **b**

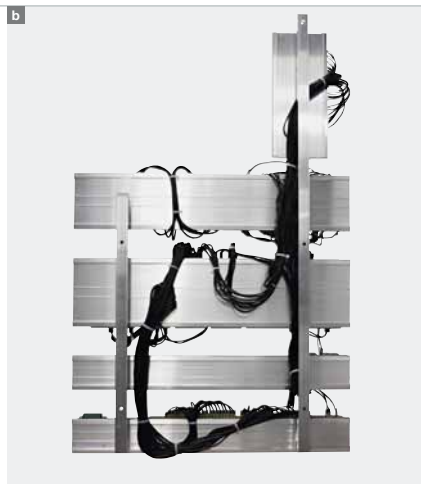
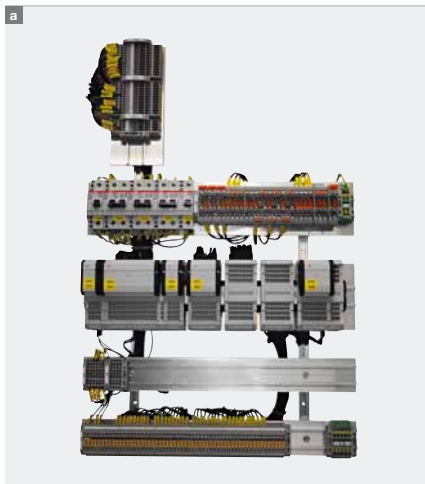


Innovative connections

The X-Plug replaces complex wiring with a simple plug



3 Front **a** and rear **b** sides of the X-Plug wiring frame



increases uniformity in terms of cable lengths, permitting cable harnesses to be used instead of individual cables. **3** shows the front and rear sides of a wiring frame using X-Plug technology. The environment of the X-Plug is completely standardized, and customization is managed inside the plug.

Reprogramming requires only a simple change of plugs, thus greatly reducing downtime and the risk of wiring errors.

One of the great strengths of this approach is that cabinets can be easily reprogrammed. All it takes for such reprogramming is a change of plugs, without any wires having to be

touched, thus greatly reducing downtime and the risk of wiring errors (especially if the X-Plugs are delivered to the site preconfigured and pretested).

It is possible for example, to change an incomer panel to an outgoing feeder or double busbar functions to single busbar functions simply by substituting X-Plugs with a different coding.

Inside the X-Plug

The X-Plug can be preconfigured, reducing installation time, yet it remains modifiable so that the customer need not sacrifice any of the flexibility that conventional wiring offers.

Inside the X-Plug is a regular matrix of terminals. The basic module is four-level (the terminal blocks are arranged on four horizontal levels)

and is available in widths of four, eight and 16 terminals.

These terminals can be interconnected horizontally, vertically and diagonally using jumper plugs.

Using the X-Plug

The X-Plug is exclusively designed for ABB and is IP (intellectual property) protected.

By the end of its first month on the market, 390 ZX panels with X-Plug terminals had been designed by ABB, accounting for 86 percent of panel orders in August 2009. These panels were shipped to chemical industries, utilities and mining businesses, greatly reducing the amount of on-site configuration required while giving customers unprecedented flexibility in making modifications and so protecting the value of their investment.

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One ABB on the Web

Increasing the quality of customer services is
what this platform does best

Jan Anders Solvik, Håkan Wårdell, Nathan Becker

As far as most of us are concerned, the Internet has become a valuable source of information. For potential customers it's where they research products and services, look for answers and get hold of documentation. Existing customers use the Web to track orders, look for training courses, keep up with industry trends and find product documentation, while employees can easily access relevant and up-to-date information. A Web site is without doubt the best and most environmentally friendly advertising brochure a company can utilize.

Accessibility and usability are two very important criteria that existing and prospective customers, partners and employees are looking for in today's fast-paced world. They want to find the right information quickly and easily, irrespective of location or the number of back-end applications or services that are used. In other words, the content of a Web site should be tailored to satisfy local needs and deliver local marketing messages while at the same time it should exhibit a common global look and feel.

This is something ABB has accomplished. Through its One ABB on the Web platform, the group is able to serve a global audience through a single access point, www.abb.com.

Innovative connections

How can a company facilitate closer collaboration with its existing customers, continue to attract new customers, and at the same time address the needs of its partners and employees? Servicing these specific target groups with a common look and feel is not an easy task. When an online visitor accesses a particular Web site, they expect to find a range of information about products, services and solutions related to their industry and country, and preferably in their local language. In many cases what the visitor actually discovers is something quite different: Often they are faced with having to remember different URLs, work in different interfaces, and manage different usernames and passwords for the various applications they wish to use. As time is a very precious resource, this visitor will probably abandon their search and move from being a potential customer to becoming a competitor's customer.

Accessibility and usability of a Web site are two very important criteria that people are looking for in today's fast-paced world.

Five years ago, this was the story ABB was hearing from its customers, and in response the group decided to re-

vamp its Web offering to meet their demands. Today, abb.com presents the ABB Group's wide range of products and services in a consistent fashion. Building on a single platform known as One ABB on the Web, abb.com is both a global and local source of information for different user groups through a single point of entry. ABB's Web platform is built on a flexible architecture that enables new services with a consistent and standardized look and feel to be easily connected. More importantly, by maintaining information about its complete portfolio in one common solution, ABB is able to serve customized information to everyone. Users are able to find information about ABB products, services and solutions related to their industry and country. In addition, the use of a standardized Web interface and common interaction elements help bring about an awareness of applications and services that were unknown to many.

For secure information, the One ABB platform offers the single sign-on (SSO) mechanism for authentication and authorization services. Now users can access their ABB Web applications and services with the same username and password.

Guiding the customer

The One ABB platform offers a range of customer services, such as training-course locators, extranets for its part-

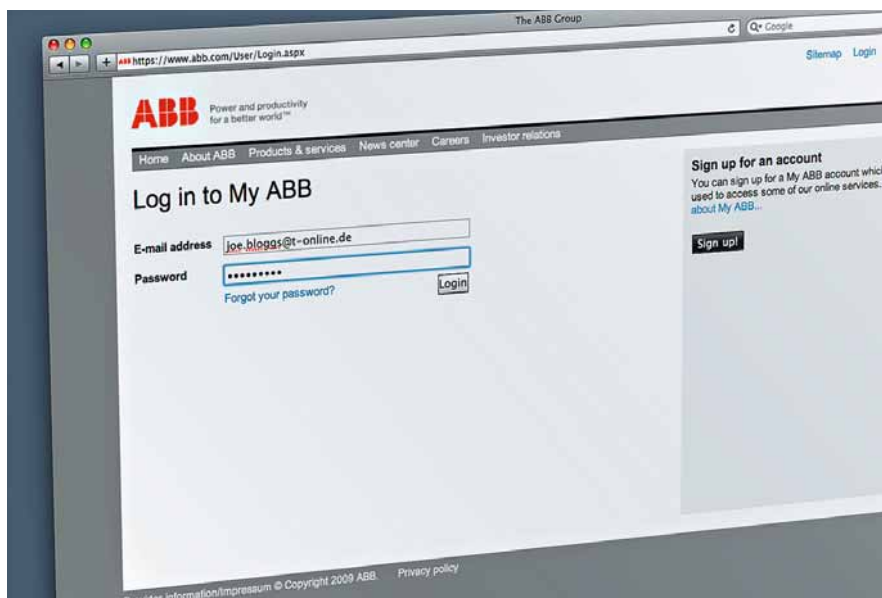
ners, direct access to installed ABB equipment and the possibility of ordering products, spare parts and maintenance packages. All of the features are maintained using different back-end applications and services. The One ABB platform allows these different services to disseminate information while adhering to a common look and feel. The advantage of having a standardized Web interface and a common interaction element is that it speeds up the learning process for those using the services for the first time. The requested information is collected and made available via the My ABB portal, which customers can access directly on www.abb.com.

ABB's One ABB on the Web platform is built on a flexible architecture that enables new services with a standardized look and feel to be easily connected.

Localization of abb.com

As is the case with many international companies, ABB maintains a local presence in many countries so that it can better understand and respond to customer needs. This local presence also extends to the abb.com Web site. The capabilities of One ABB on the Web enable:

- The translation of products, solutions and services: Because a majority of users prefer to read the content in their native language, translating the portfolio will provide a better user experience for customers.
- The addition of local products: A local unit can add products made to support local standards. These products are generally not available in other countries and regions.
- The exclusion of non-relevant products: Products that do not conform to local standards or that are not relevant to a particular market can be excluded.
- The viewing of localized documents: In many cases documentation is only relevant to a specific country or countries. The One ABB platform supports the presentation



of these documents to visitors only if they are affiliated to the authorized countries.

- **Local contacts:** A central database supplies the customer with the name of a local contact based on his preferences.
- **Localized page:** By setting up a country-specific page, it is possible to highlight events and campaigns that are only available locally. This page will only be shown if the user has set this country as their preference.

Technical realization in a nutshell

For Web content delivery and integration with back-end systems, the One ABB on the Web platform is based on Microsoft's well-known ASP.NET¹⁾ and corresponding technologies, such as SQL Server and Active Directory. Integration is focused on open interfaces, which are based on Simple Object Access Protocol (SOAP) and Representational State Transfer (REST) principles. Security is implemented using Web Services Security (WS-Security) and Security Assertion Markup Language (SAML). IBM's Lotus Domino is used to manage Web content, which is delivered to ASP.NET using Extensible Markup Language (XML).

With the One ABB platform customers can access installed ABB equipment and order products, spare parts and maintenance packages.

The two key methods for integrating an application with One ABB are ASP.NET control and Context Service Consumer. These simplify user management and customer access **1**.

ASP.NET control (Web control)

ASP.NET utilizes a wide range of controls, which are effectively like a toolkit for Web designers, allowing them to provide increased functionality as well as an enhanced visual appearance

in their applications. Two such controls, user and Web server, are used extensively by the One ABB platform. Web-server controls enhance both visual appearance and functionality, while user controls are created by the Web designer to provide the functionality missing in built-in ASP.NET Web-server controls.

For Web content delivery and integration with back-end systems, the One ABB platform is based on Microsoft's ASP.NET.

One or more ASP.NET Web controls²⁾ are developed and embedded in the One ABB portal pages **2**. Typically, these controls should produce a lightweight user interface that can communicate with a back-end Web service, which contains the business logic for the application. The application provides a precompiled ASP.NET 2.0 user control that also runs on the One ABB portal.

Context service consumer (Web service)

One ABB on the Web offers a Web service that provides an HTML context for the application. This approach is favored if the application has its own hosting environment and is not developed in the .NET environment.

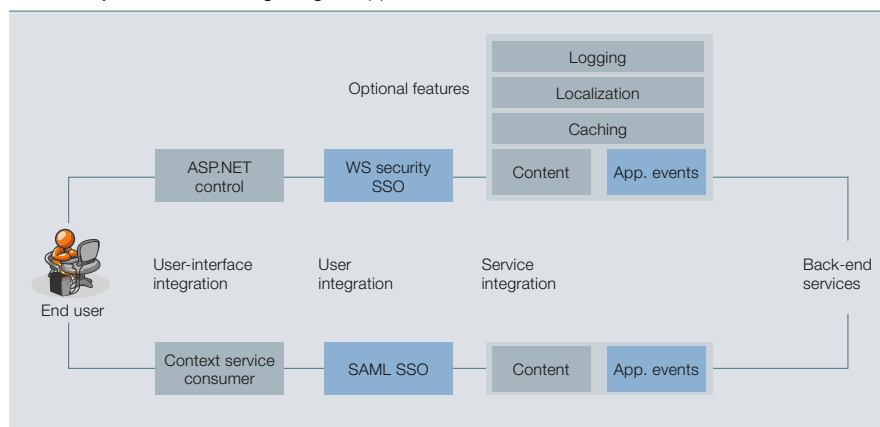
The application sends a request to the service to retrieve the appropriate html context **3**. The html context generally contains:

- Style information (ie, style sheets and corresponding style elements)
- Top and left menus
- Other context information such as username and general common look-and-feel elements

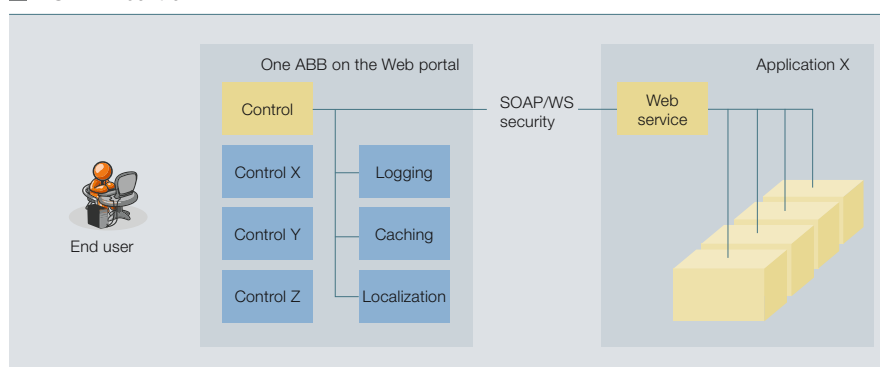
The service currently provides the following contexts:

- MyABB (top and left menu, and login information)
- Product details (top menu, product hierarchy breadcrumb, language/country selector, product detail tabs)
- Language/country selector (together with a top menu)

1 Two key methods for integrating an application



2 ASP.NET control



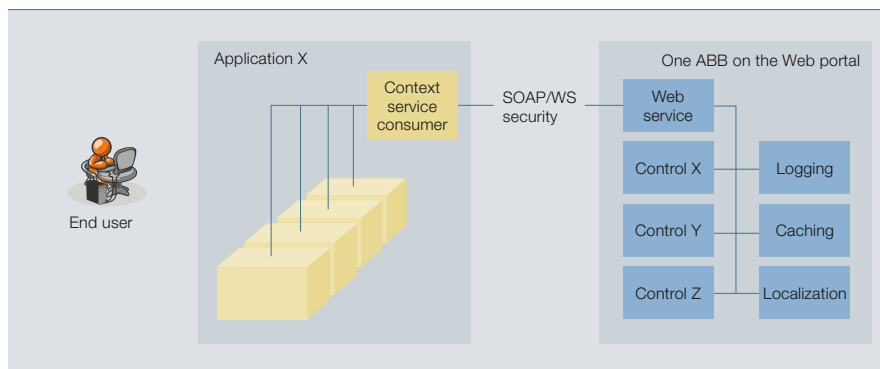
Footnotes

¹⁾ Current version is 3.5.

²⁾ The controls are deployed with each major One ABB on the Web release.

Innovative connections

3 Context service consumer

**Single sign-on (SSO)**

SSO ensures that all abb.com users, irrespective of whether they are employee, partner or customer, access their information and services with a single username and password

Factbox 1. The advantages of implementing SSO also include:

- Forgotten passwords are managed on behalf of all services.
- All requirement concerning the security of username/password combinations are handled in one place and strictly follow the ABB security policy.
- Changes to user data are synchronized with all integrated services.
- There is one common process for managing user accounts.

However, managing users goes much further than just enabling a single login to several applications or services. With each user requiring authentication

only once, the next logical step is to consolidate the service-specific authorization capability.

Common Authorization Management is fast becoming an important component as ABB transitions into a Service-Oriented Architecture.

Service-specific authorization is important in providing customers and users of ABB Web applications with the functionality and services they need. By managing user rights, roles and responsibilities in a common tool, ABB is able to tailor the functionality provided by several applications so that it can offer customized services to meet the needs of specific users and

user groups. Additionally, by enabling ABB personnel (who manage users across different applications) to do this via one interface increases efficiency and improves data access security.

ABB's One ABB on the Web platform has enabled the many ABB businesses to streamline their information, quotation and ordering processes.

This common online tool is provided by a Common Authorization Management (CAM) software architecture. CAM is fast becoming an important component as ABB transitions into a Service-Oriented Architecture (SOA), and it will support the modularization of applications that will have the ability to exchange data with one another using data packages of interoperable services.

CAM architecture and design

CAM was built on existing functionality and experience coupled with future business-specific needs. As ABB continues to implement its One ABB on the Web group concept it is important that a common user authorization framework is used to quickly, efficiently and securely manage user access rights for the different applica-

Factbox 1 Single sign-on (SSO) user types**Self-registered**

The user identity is not confirmed. The account was created over the Internet by registering on abb.com. Therefore the only valid attribute of such a user is the e-mail address.

Managed

The user, typically one who accesses business-specific services, has a confirmed identity with ABB. Security restrictions apply when user details need to be changed.

Internal (ABB employees)

Employees are integrated with ABB's Active Directory.

Factbox 2 ABB's Business Online application offers the following services:

- Online ordering capability 24/7
- A single interface to over 450,000 ABB products with supporting documentation and images (products and parts are country, region and channel dependent)
- Integration into ABB "configurators for custom products"
- Customized product catalogs
- Parametric product search capability and real-time stock availability
- Customer-specific pricing
- Request for a quotation
- A fully integrated quotation creation and approval process for fully configured, standard and local products
- Ability to convert quotations to orders
- Single-order entry and fully integrated order-change process
- Order routing to the different local ABB business units
- Real-time "chat" capability with ABB personnel
- Repair order processing
- Warranty order processing
- Emergency ordering
- Purchase order and credit card payment options
- Automatic e-mail notification
- Order status and history
- Fault and failure reports
- Real-time shipment traceability
- Extensive reporting

tions and services [4]. In addition to groups, CAM introduces a flexible structure for creating attributes, which can be attached to any application based on its needs. The attributes can hold single or multiple values and be of any type. The CAM user interface has the same look and feel as abb.com, which must fulfill the same purpose.

Doing "Business Online" with ABB

Business Online is an example of one abb.com integrated application using both SSO and CAM. It was redesigned in 2008 in accordance with ABB's SOA strategy. The new architecture is based on Asynchronous JavaScript and XML (AJAX), which creates a dynamic and lightweight application. This technology introduces the concept of modularization, which drastically im-

proves Web page performance while significantly reducing network traffic by limiting the amount of data that needs to be transferred.

Combining AJAX and dynamic HTML (DHTML) with server-side computing has added easy-to-use functionality. Some examples of this technology are

4 Common Authorization Management (CAM) architecture

Architecture

- Model layer: home made persistence API: easy migration to latest JPA
- GUI layer: struts
- Web services

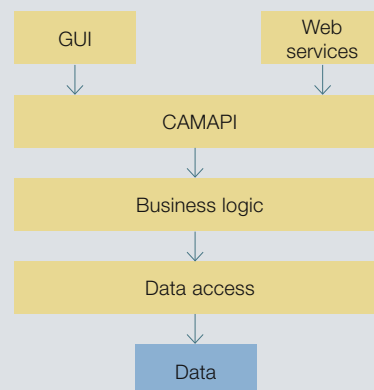
Environment

- Application server

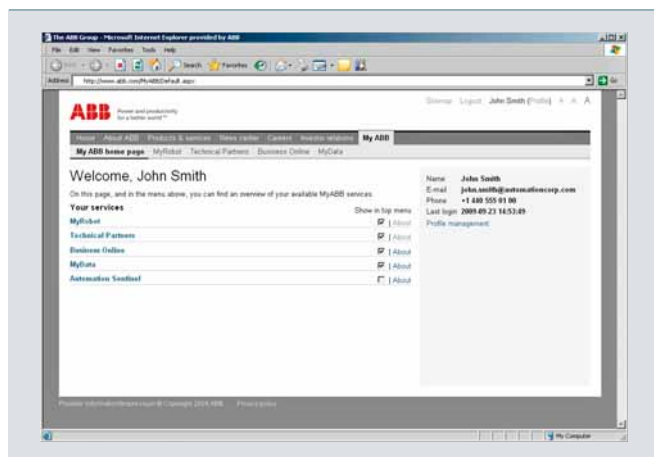
WebSphere with Java

- Database

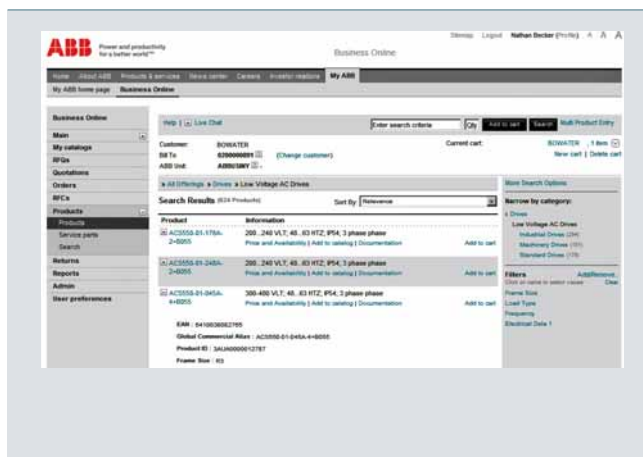
Oracle



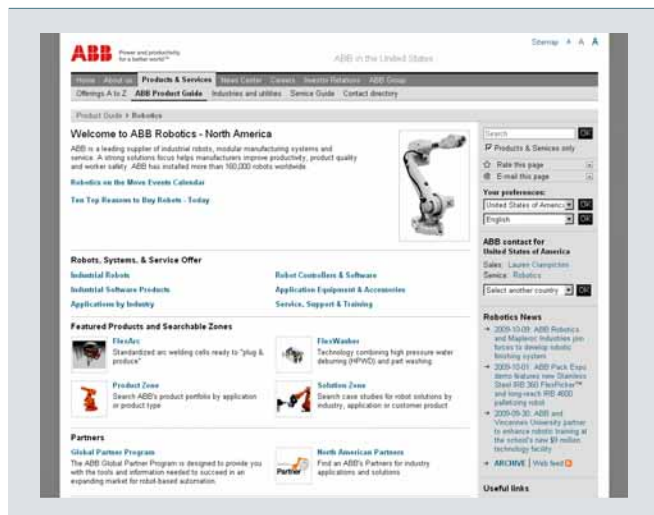
With a MyABB account customers can take control of the way they do business with ABB



Ordering online reduces manual work and minimizes mistakes



Localization of ABB: a country-specific page for North America



A typical country-specific page for Switzerland



Innovative connections

evident throughout the ABB online ordering tool:

- **Searching products:** The product number automatically populates as the user enters an identifier, narrowing down the options with each typed character.
- **Drag and drop:** Products can be easily moved from search result pages to the shopping cart.
- **Pricing and availability:** Real-time Web services access back-end business systems.
- **Images and documents:** Real-time Web services access product image and document management systems.

Business Online is now fully integrated into the group Web site, enabling ABB to offer more consolidated online services to its customers **Factbox 2**.

Coming back for more

ABB's goal with its One ABB on the Web platform has been to increase the quality of its customer service by helping different user groups find the information they need in the fastest possible time. In addition it enables the many ABB businesses to streamline their information, quotation and ordering processes. Online business has been and will continue to be the way forward, so making it easy for the user is one way of ensuring they'll come back.

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Glossary

Active Directory

is a directory structure used on Microsoft Windows-based computers and servers to store information and data about networks and domains. It is primarily used for online information.

(Source: <http://www.tech-faq.com>)

AJAX

is short for Asynchronous JavaScript and XML, and is used when a designer wants his Web page to retrieve new information from the Web server asynchronously in the background without having to download a whole new page.

(Source: <http://javascript.about.com>)

ASP.NET

is a Web application framework developed and marketed by Microsoft to allow programmers to build dynamic Web sites, Web applications and Web services. ASP.NET is built on the Common Language Runtime (CLR), allowing programmers to write ASP.NET code using any supported .NET language.

(Source: Wikipedia)

Microsoft SQL Server

is a relational model database server produced by Microsoft. Its primary query languages are T-SQL and ANSI SQL.

(Source: Wikipedia)

REST

is an acronym standing for REpresentational State Transfer. Roy Fielding, who coined the phrase to describe an architecture style of networked systems, says that REST "is intended to evoke an image of how a well-designed Web application behaves: a network of Web pages (a virtual state-machine), where the user progresses through an application by selecting links (state transitions), resulting in the next page (representing the next state of the application) being transferred to the user and rendered for their use."

(Source: <http://www.xfront.com>)

SAML

stands for Security Assertion Markup Language and is an XML-based framework for communicating user authentication, entitlement, and attribute information. It has become the definitive standard underlying many Web Single Sign-On solutions in the

enterprise identity management problem space.

(Source: <http://xml.coverpages.org>)

SOA

or Service-Oriented Architecture is essentially a collection of services that communicate with each other. The communication can involve either simple data passing or it could involve two or more services coordinating some activity.

(Source: <http://www.service-architecture.com>)

SOAP

or Simple Object Access Protocol is a protocol specification for exchanging structured information in the implementation of Web services in computer networks. It relies on Extensible Markup Language (XML) as its message format, and provides a way to communicate between applications running on different operating systems, with different technologies and programming languages.

(Source: Wikipedia)

WS-Security

or Web Services Security is a communications protocol providing a means for applying security to Web services. It describes how to attach signatures and encryption headers to SOAP messages as well as how to attach security tokens, including binary security tokens such as X.509 certificates and Kerberos (a computer network authentication protocol, which allows nodes communicating over a non-secure network to prove their identity to one another in a secure manner) tickets, to messages.

(Source: Wikipedia)

XML

(Extensible Markup Language) is a simple and very flexible text format derived from SGML (ISO 8879). Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the Web and elsewhere.

(Source: <http://www.w3.org/XML>)



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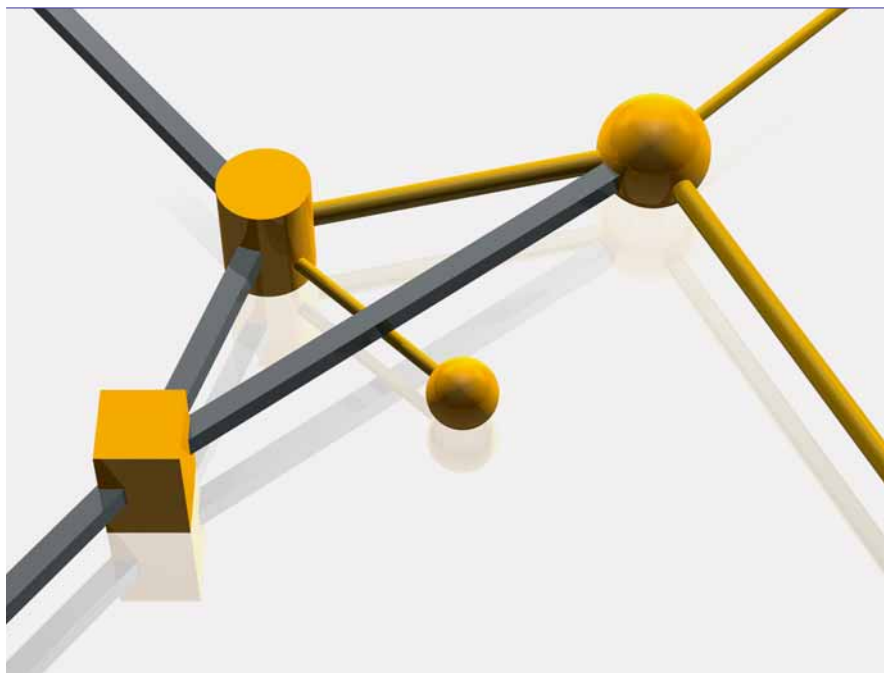
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Preview 1/2010



Smart grids

Typical power grids feature large power plants delivering power to consumers in their extended area. Power flows are predominantly one-way and supply is tailored to follow demand. The fundamentals of this model have remained basically unchanged since the early days of power transmission.

Changing conditions are calling for a rethink of this approach. One of the factors influencing this is the rise of renewable energy fueled both by environmental awareness and concerns over carbon dependency. A challenge of the large-scale integration of wind and solar energy into grids is that their supply is intermittent and difficult to predict. Furthermore, their generation is often in locations that are far from the major load centers and where the grid is traditionally weak.

A further factor affecting future transmission networks is liberalization, which is leading to increased power trading and consumers being able to choose the source of their power – placing additional pressure on transmission networks.

The grid of the future must be able to handle increased long-distance power flows safely and reliably. This calls for technologies that can enhance grid capacity and stability. There will be a move away from centralized power sourcing and one-way flows to more distributed generation and two-way flows. The increased complexity of controlling such a grid calls for advanced monitoring equipment along with the associated control strategies.

ABB has the technologies, products, services and strategies to respond to these demands. These will be the focus of issue 1/2010 of ABB Review.



Connect emission-free power to the grid?

ABB is helping construct the world's largest offshore wind farm. Using our eco-friendly transmission technology, this 400-megawatt plant is expected to avoid 1.5 million tons of CO₂ emissions per year and improve the reliability of the power grid. It's just one of the ways that we, as the biggest supplier of electrical products and services for the wind industry, can use renewable power sources to help combat climate change. www.abb.com/energyefficiency

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